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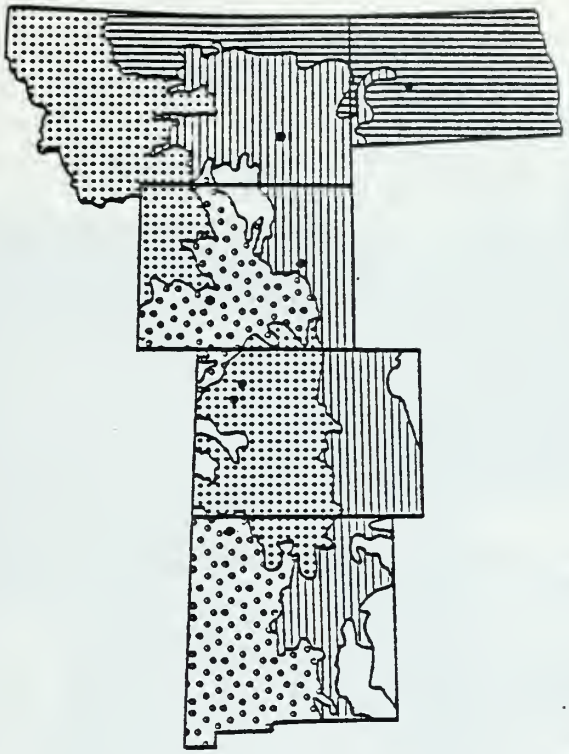

# Evaluation of Ongoing Mined-Land Reclamation on Selected Coal Mines in North Dakota, Montana, Wyoming, New Mexico and Colorado

Report 31 - 1979
U.S. Department of the Interior
Bureau of Land Management

University of Idaho
College of Agriculture
Moscow, Idaho

CONTENTS


Page

Introduction . . . . . 1
Location Map of Study Areas . . . . . 2
Reclamation Summary . . . . . 3
    Indian Head Coal Mine . . . . . 3
    Rosebud Coal Mine . . . . . 4
    Dave Johnston Coal Mine . . . . . 5
    Seminoe Coal Mine . . . . . 7
    San Juan Coal Mine . . . . . 8
    Edna Coal Mine . . . . . 10
    Energy Coal Mine . . . . . 11

Physical and Reclamation Data (General Site Data and Physical Profile) . . . . . 13
    Indian Head Coal Mine . . . . . 13
    Rosebud Coal Mine . . . . . 17
    Dave Johnston Coal Mine . . . . . 24
    Seminoe Coal Mine . . . . . 28
    San Juan Coal Mine . . . . . 31
    Edna Coal Mine . . . . . 35
    Energy Coal Mine . . . . . 40

Reclamation Prescription . . . . . 45
    Land Resource Region F . . . . . 45
    Land Resource Region G . . . . . 47
    Land Resource Region D . . . . . 55
    Land Resource Region E . . . . . 60

General Recommendations . . . . . 63

References Cited . . . . . 65

Personal Communications . . . . . 66

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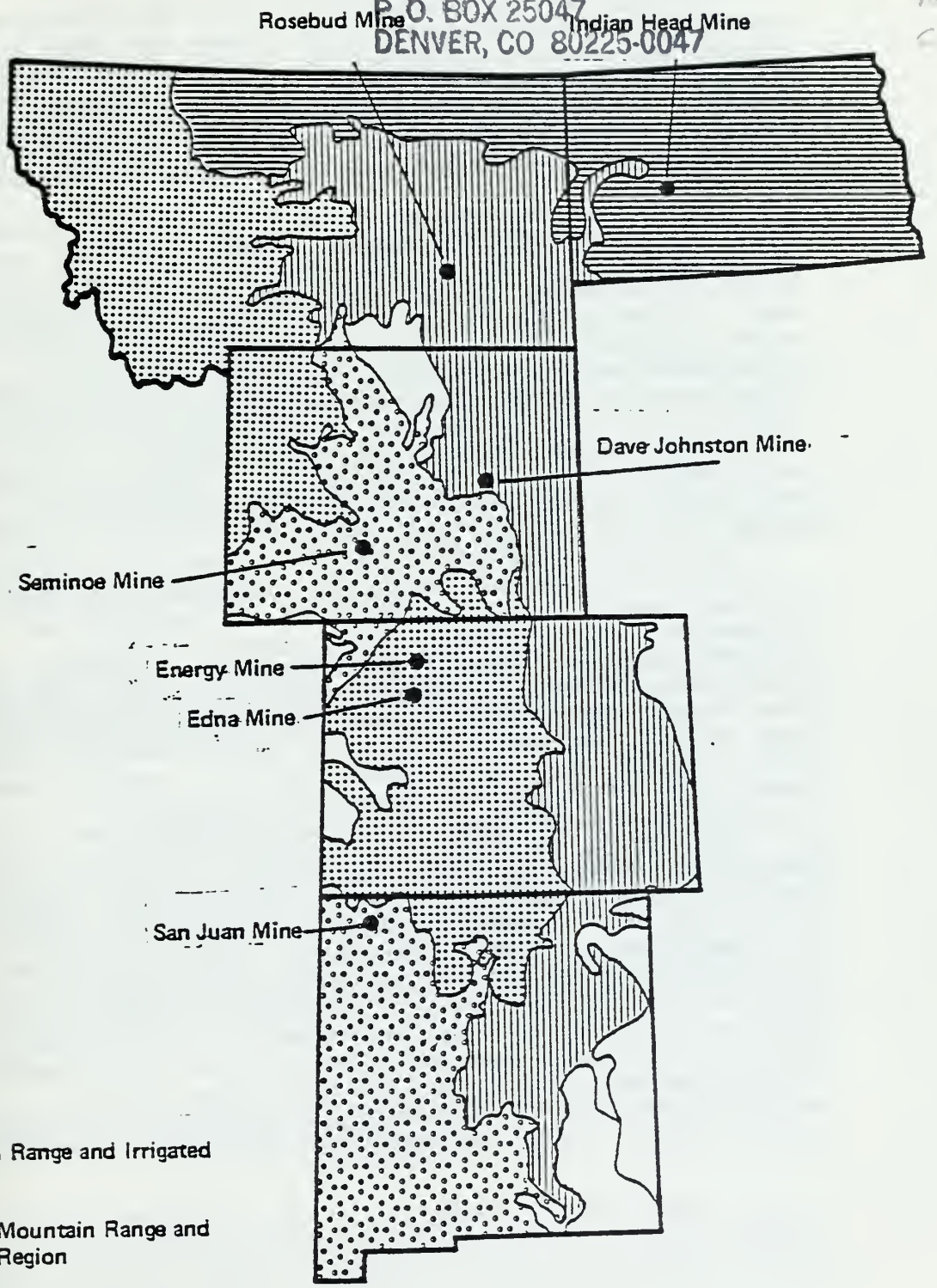


Fig. 1. Location map of mines and major land resource areas.

# INTRODUCTION

The Bureau of Land Management concluded from discussions between WO (350) and DSC (D-310) that a system was needed to evaluate strip mined-land reclamation. Predictive methodologies have not been adequately evaluated or tested. The Bureau needs assurance that lease stipulations for coal leases are reliable and practical. A reclamation standard needs to be identified and a reclamation prescription developed by major land resource area.

A study plan was developed by the Watershed Staff (D-350), Denver Service Center, that proposed methods to evaluate ongoing reclamation at selected coal strip mines within the major land resource areas having important coal resources. The objectives were: (1) to evaluate ongoing reclamation procedures used by the mining companies and/or identified by stipulations in the reclamation plan, (2) to identify the reclamation standard, and (3) to develop a reclamation prescription for the major land resource areas of the Northern Great Plains, Western Great Plains, Western Range Regions, and Southern Rocky Mountains. Field work was conducted in June 1978 by Dr. Maynard A. Fosberg, professor of soil science at the University of Idaho in Moscow under contract to BLM.

The following methods were used: (1) Seventy questions were developed based in part on the BLM Handbook, "Guideline for Reclamation," for a systematic data collection procedure. (2) Seven mines were selected, which included: Indian Head Mine, North American Coal Corp., Beulah, North Dakota 58523; Rosebud Mine, Western Energy Corp., Colstrip, Montana 59323; Dave Johnston Mine, Pacific Power and Light Co., P.O. Box 398, Glenrock, Wyoming 82637; Seminoe Mine #1, Arch Mineral Corp., P.O. Box 459, Hanna, Wyoming 82327; San Juan Mine, Western Coal, P.O. Box 509, Farmington, New Mexico 87401; Edna Mine, Pittsburg-Midway Mining Co., P.O. Box 176, Oak Creek, Colorado 80467; and Energy Mines, Energy Fuels Corp., P.O. Box G, Steamboat Springs, Colorado 80477. The mine locations are given in Figure 1 on the Regional Land Resource Map. (3) Conference arrangements with mine personnel were made in advance by BLM personnel. (4) At each conference, the investigator was accompanied by a BLM EMRIA representative or local district reclamation specialist. First, the investigator explained in detail the purpose and objectives of the inquiry to the mine superintendent and the reclamation specialist. Second, the mine reclamation specialist conducted a mine tour and explained their reclamation activity, including the equipment use and the results of their reclamation procedures.

## RECLAMATION SUMMARY

Indian Head Mine, Beulah, North Dakota

Premining land use for Indian Head Mine area was rangeland and cropland. Reclamation is mainly oriented toward range or pasture and some crops.

### Factors Affecting Reclamation

1. Mean annual precipitation (MAP): Approximately 16 in. and mean annual temperature (MAT) is 40 to 41° F with approximately 120 frost-free days; the elevation is 1790 feet.
2. Geology: Consists of the Sentinel Butte and Tongue River Formations, which are high in clays and sodium salts, at the terminus of end moraines.
3. Soil: Fine-textured and strongly influenced by sodium salts below 30 in.
4. Native vegetation potential: Kuchler's type 66. This is the midgrass community that includes western wheatgrass (Agropyron smithii), green needleandthread (Stipa comata), and little bluestem (Andropogon).

Reclamation potential is moderate with major problems from high clayey and sodium-influenced soils and spoils. The result is differential settling, piping, soil dispersion and erosion, and seedling establishment.

### Reclamation Practices, Sequence, and Timing

1. Topsoil: Removed in two lifts by scrapers: first, the surface 6 in. and second, the rest of profile into upper part of C horizon. Soil is stockpiled in two piles.
2. Spoil piles: Spread and reshaped with bulldozers.
3. Shaped spoil: Topsoiled in reverse order of removal.
4. Seedbed: Prepared.
5. Seed mix: Drilled.

Cultural practices not used are: Discing, gouging, terracing, ripping, and mulching.

The company's effort in reclamation is outstanding. Using a grid system and high intensity soil surveys for topsoil removal and a landscape plan for reshaping spoil are desirable practices. An additional practice which might be beneficial based on research results and which was initiated by the company is the use of fertilizers for vegetation establishment and large quantities of gypsum worked into the seedbed prior to seeding. Stockpiling

topsoil should be avoided if it were possible to lift and spread in one operation, which could provide greater benefits from native species when noncultivated lands are mined. Mulching with materials grown on the site for steeper slopes may be a desirable practice; this would retard erosion while the vegetation is being established. Developing multipurpose water ponds for wildlife habitat is an outstanding practice.

It is recommended that the old spoil area from mining prior to reclamation requirements not be disturbed. The habitat created has great value to existing deer herds and other wildlife not present prior to mining.

## Rosebud Mine, Colstrip, Montana

Premining land use for the Rosebud mining area was dominated by native range with small amounts of cropland. Rock outcrop and thin soil areas have stands of slow growing Ponderosa pine.

### Factors Affecting Reclamation

1. MAP: 16 in.; MAT: About 42° to 45° F; frost-free days about 110 to 120. Elevation: 3400 ft.
2. Physiography: Undulating to hilly. Geology consists of sedimentary rock of sandstone and siltstone with coal from Rosebud Formation.
3. Soils: Coarse-loamy, fine-loamy, and loamy-skeletal families and moderately deep; they are Haploborolls-Ustorthents.
4. Native vegetation potential: Kuchler's type 64; this is a grama-needlegrass-wheatgrass with some plains or silver sagebrush (Artemisia cana).

Reclamation potential is moderately high and revegetation programs, started in 1976 with the latest technology, have been successful. The major problems are erosion on steeper slopes and excessive surface-water runoff.

### Reclamation Practices, Sequence, and Timing

1. Topsoil: Removed by scrapers in two lifts; timing avoids stockpiling whenever possible. Soil is removed to a depth of 2-1/2 to 3 ft.
2. Grading and shaping of spoils: Done by bulldozers. Headwalls are graded to a 5-to-1 slope.
3. Seedbed is prepared in the following way:
   a. Chiseling is done on majority of slopes which are less than 7 to 1 alleviate compaction in the rooting zone and increase infiltration and reduce surface runoff.
   b. Straw mulch is applied at 1-1/2 tons/A.

c. Fertilizer is applied at a rate of 175 lbs/A of 18-46-0. The second year, 200 lbs of 16-20-0 is applied.

d. Area is disced to crimp straw and cover the fertilizer.

e. Seeding is completed and area is cultipacked. Steeper slopes are chiseled, seeded, packed, and hydromulched with wood fiber. Some steep slopes are gouged. Seeding is done both in the spring and in the fall. The seed mixture contains about 16 species, including many native species and "winter graze" for added winter cover.

f. Native sod is placed in drainageway bottoms that are subject to accelerated erosion.

g. Trees and shrubs are transplanted along drainageway positions for reestablishing riparian and wildlife habitat.

h. Reclamation area is fenced and no grazing is permitted.

This reclamation program and its success are outstanding. The two reclamation specialists are proud of their accomplishments and they have strong company support. The climate, moderately thick soils, and an overburden without toxic or salinity problems make ideal conditions for successful revegetation. Species planted should contribute to a plant community that will permit regeneration. The company used "winter graze" (a sterile winter annual hybrid wheatgrass-wheat cross) and drainageway sodding for added erosion control. Old erosion scars are being repaired with erosion blankets.

State regulations prevent any type of surface-water development. This regulation should be modified to permit onsite developments for those mines without toxic problems. The Rosebud Mine would prefer to make multipurpose water development for erosion control, wildlife, livestock, and mine operations, which could be accomplished with little additional cost during the spoil shaping. The company would be interested in a controlled grazing management plan, which has been found by research to be beneficial in thickening vegetation cover. Hydromulching is required by Montana regulations on steeper slopes. Company reclamation specialists indicated that this is a poor practice because hydrofiber washes off slopes; it is not as effective as straw mulch crimped into surface.

Dave Johnston Mine, Glenrock, Wyoming

Premining land use for the Dave Johnston Mine area was native rangelands and reclamation is oriented toward rangeland use.

## Factors Affecting Reclamation

1. MAP: 10 in.; MAT: Estimated at 40° F; frost-free season is 90 days.
2. Physiography: Undulating to hilly with an average slope range of 6 to 12 percent and, in some places, exceeds 20 percent. Subbituminous C rank coal comes from Fort Union Formation in the Badger and Hanna seams; the elevation ranges from 5200 to 5400 ft.
3. Soils: Sandy and shallow but have deep, underlying, loose sandy sediments that would be suitable for (thicker cut for) topsoiling.
4. Native vegetation potential: Kuchler's type 56, which is shrub steppe. Major species are Wyoming big sagebrush (Artemisia tridentata), western wheatgrass, and needleandthread.

Reclamation potential is relatively poor with major problems of low precipitation and shallow, sandy soils.

## Reclamation Practices, Sequence, and Timing

1. Topsoil: Stripped by scraper in one lift.
2. Reshaping of spoils: 3-to-1 slope by bulldozer guided by visual relationship of landscape.
3. Deep ripping of reshaped spoil: On the contour.
4. Topsoiling: To an average depth of 6 in. on a rough-ripped surface.
5. Seedbed: Chisel-plowed.
6. Millet mulch crop: Planted in spring.
7. Seeding: In the fall. Seed mix consists of three species: fairway crested wheatgrass (Agropyron cristatum), thickspike wheatgrass (Agropyron dasystachyum), and fourwing saltbush (Atriplex canescens). Grasses are drilled and fourwing saltbush broadcasted.
8. Fencing surrounds all reclaimed areas.

Practices not used are: Discing, gouging, basins, terracing, straw mulching, and fertilizing.

The reclamation specialist is competent and does well considering that he is the only permanent employee doing reclamation. All reclamation practices are carried out during slack periods in the coal mining process. Timing is a critical problem, so the company is trying to develop a logical sequence to the reclamation success.

A unique practice developed at the Dave Johnston Mine is the use of millet as a mulch crop prior to seeding. Planting into the millet stubble is done in the fall and is a successful practice in this droughty area. It provides food and protection for birds and other kinds of wildlife.

Recommendations are:

1. Soil should be lifted in two loads. The first lift should include the top 6 in. and the second lift should extend to at least 32 in. This would include part of sandy C material that is suitable for topsoil.
2. More native species should be included in the seed mix, such as a palatable sagebrush and western wheatgrass.
3. Company should provide more permanent employees for reclamation, which would help greatly the timing and quality of the work. The practice of using millet as a mulch crop is far superior to straw mulch and the use of a winter grain mulch should also be considered. The area is too dry for fertilizer use in reclamation.

## Seminoe Mine #1, Hanna, Wyoming

Premining land use for the Seminoe Mine was native rangeland and reclamation is oriented to this use.

### Factors Affecting Reclamation

1. MAP: 11 to 12 in.; MAT: Estimated at 40° to 42° F and the frost-free period is about 70 to 80 days. The elevation ranges from 7000 to 7300 ft.
2. Physiography: Undulating to rolling with 6 to 10 percent slopes. Most coal is the bituminous C rank and some subbituminous C. These occur in the Ferris Formation which is made up primarily of sandstone, siltstone, and shale.
3. Soils: Dominantly sandy and relatively shallow. The C material is suitable for topsoiling.
4. Native plant communities identified by Kuchler: Type 56 shrub steppe with dominant species of Wyoming big sagebrush, western wheatgrass, and needleandthread. Some drier areas have large amounts of shadscale.

Reclamation potential is relatively poor with major problems of low precipitation and shallow sandy soils; however, good vegetation stands can still be established.

### Reclamation Practices, Sequence, and Timing

1. Topsoil: Removed in one lift and stockpiled with a scraper.
2. Spoil: Graded and shaped by bulldozers; topography is shaped by visual inspection.
3. Topsoil: Roughly spread with a scraper and uniformly spread by grader with blade.

4. Terraces: Developed at the time of final grading.
5. Annual grain: Drill-planted in the spring for a mulch crop.
6. Grass mix: Drilled into the grain stubble mulch in the fall.

Practices not used: Fertilizing, fencing, irrigation, basin development, discing, ripping, and gouging.

## Evaluation

Reclamation specialists, as a team, appear to be doing a fair job but are inexperienced in the problems of the semiarid conditions. They were recently required by the state to use a more complex seed mix than used in the past when only crested wheatgrass was acceptable. These old stands were reasonably good under abnormally dry climatic conditions, but plants were quite widely spaced, producing much bare ground.

The purpose of the terrace ridge is to retard downslope surface-water movement, which the reclamation specialist indicated was a very effective practice in normal years. During 1978, higher than normal precipitation occurred and the terraces broke in numberous places, causing accelerated erosion.

## Recommendations

It is recommended that topsoil be removed in two lifts. The lower lift (second lift) should include some of the sandy C material for lower replaced topsoil to give a greater depth over the shaped spoil. The upper six inches (first lift) should be placed on the surface, which provides greater moisture storage, places the original surface soil with best structure at the surface for best water intake properties, and provides a seed source for native plant species. Native species that should be added to seed mix are a palatable big sagebrush and shadscale. It is strongly recommended that large boulders be used for resting and mating sites for raptors and that piles of stones be used for small mammal habitat. The company's practice of growing mulch is superior to straw mulch brought into site. Millet, as used by Dave Johnston Mine, is a better species for mulch than spring grain. The area is too dry for a fertilizer response in the reclamation program.

## San Juan Coal Mine, Farmington, New Mexico

Premining land use for the San Juan Mine was native rangeland, and reclamation is oriented to this use.

## Factors Affecting Reclamation

1. MAP: 7 in. with intense summer rainfall patterns. Potential evapotranspiration is approximately 50 in. per year; frost-free days per year are approximately 150; MAT: Approximately 50° F; elevation is 5200 ft.

2. Physiography: Gently undulating and hilly with slopes in reclamation areas of about 3 percent. The coal is bituminous C and B from Kirtland and Fruitland Formations of Late Cretaceous age which are soft sandstones and hard shales.

3. Soils: Generally sandy loams to clay loams that are 12 to 18 in. thick. Some badland areas have no topsoil, while drainage bottom positions have thick accumulations of sandy soils.

4. Native plant community identified by Kuchler: Type 40. Dominant shrubs are greasewood with shadscale (Atriplex confertifolia), blue grama (Bouteloua gracilis), and galleta (Hilaria jamesii).

Reclamation potential is poor. The major limitation is low rainfall, so irrigation is required for stand establishment.

## Reclamation Practices, Sequence, and Timing

1. Topsoil: Removed in one lift. An arbitrary thickness of 8 to 12 in. of soil is now removed and stockpiled. In the future, the total soil thickness of 12 to 18 in. will be removed in one lift.

2. Spoil: Graded and shaped by bulldozers. The landscape is shaped by visual approximation of the preexisting topography.

3. Fertilizer: Applied.

4. Spoil: Scarified by use of a ripper after topsoiling to break the interface between topsoil and spoil. Compacted spoil causes root retardation. Ripping will be replaced by a new 36-in. disc plow.

5. Seed mix: Drilled.

6. OSM requires 4000 lb/A of straw mulch. Native bluestem straw from Kansas is used instead of regular grain straw because of the high weed seed content in the straw. Mulch is spread and crimped.

7. Irrigation water: Applied at a rate of 16 in. the first year and 8 in. the second year.

8. Area: Fenced.

Practices not used: Gouging, ripping, basin and water development.

The reclamation specialist has developed a practical and successful program; he applies research developments soon after they have been proven successful. The company uses their own equipment and personnel which appear to be adequate for the job. The seed mixture is very good for this low rainfall area.

If timing permits, it is recommended that soil be removed in two lifts and replaced in two operations. It is important to preserve the A horizon even though it is thin in this area. Some of the sandier overburden possibly needs to be included in second lift. In draws where soils are much thicker, all of the suitable soil should be used for topsoiling. Mulching seems to be a problem, with a 4000-lbs/A application. This much is not needed for erosion control on gentle slopes. Consideration should be given to growing millet for a mulch crop and planting the seed mix in the stubble. This is a successful practice elsewhere in dry climates and would reduce the harmful effects of presently used straw mulch in retarding seedling establishment.

Experiments are being conducted that include a system of terraces and a ponding system for water gathering on the upper one-half of an imprinted pattern. This is to supply water for the adjoining lower half that is newly seeded. The use of this system has demonstrated an increase in yield from 175 lbs to 875 lbs/A. It would appear that this system should be established as a standard practice in this major land resource region.

Edna Coal Mine, Oak Creek, Colorado

Premining land use was rangeland and reclamation is oriented to this use.

### Factors Affecting Reclamation

1. MAP: Estimate at 24 in.; average MAT: About 40° F; frost-free period is about 57 days.
2. Physiography: Hilly with slopes from 10 to 34 percent in reclaimed areas. The elevation of the area is about 7200 ft. The Yampa Coal Field produces bituminous C coal from Cretaceous, Paleocene, and Eocene Formations.
3. Soils: Loams and very deep.
4. Native plant community: Kuchler's type 55-sagebrush-steppe with aspen stands on north and east slopes. Species are mountain big sagebrush (Artemisia tridentata vaseyana) with rich stands of Idaho fescue (Festuca idahoensis), wheatgrasses, forbs, and shrub species of rose (Rosa sp.) and snowberry (Symphoricarpos sp.).

Reclamation potential is good, with the major problem erosion.

### Reclamation Practices, Sequence, and Timing

1. Grading and shaping: Accomplished by bulldozers.
2. Topsoiling: With scrapers in which total depth of topsoil is removed in one lift and spread in one operation.

3. Topsoil: Disced and fertilized.
4. Seed mixture: Drilled in the fall.
5. Straw mulch: Applied and crimped with a disc.
6. Areas with poor germination: Reseeded the following year.
7. Gouging: Used on steeper slopes.
8. Small basins: Developed during regrading for impoundment of water and sediment retention.
9. Trees and shrubs: Planted as tubed plants.

Practices not used: Terraces, irrigation, and ripping. The company reclamation program is successful and reclamation specialists are competent.

There are several changes that are recommended for their program, and they include the following: Topsoiling should definitely be done in two lifts and in one operation if timing is right. The surface A horizon is thick, dark, and has a high potential value for supplying native seed and plant materials. It is further recommended that water be developed for wildlife and livestock. There are no problems from spoil contamination with heavy minerals. A sagebrush species should be used in seed mix. Small trees could be transplanted with front-end loaders to tree planters where native trees are available on gentle slopes. Contour furrowing should be used to stabilize surface soils, reduce erosion, and impound water. Rock piles should be used for small mammals' habitat, and bird resting sites. Mulching seems to be a problem that causes poor germination in some areas; part of this problem could be a loss of nitrates due to biological activity in straw decomposition, but this has not been tested in the BLM fertility plots. It is recommended that the use of nitrogen fertilizer be applied to the straw mulch and that consideration be given to growing a mulch crop, which is a successful practice used by other mining companies in the area. This may be important for protection of soil surface during the growing season. A winter grass could be planted in spring and seed mix planted in the straw mulch in the fall.

## Energy Coal Mine, Steamboat Springs, Colorado

Premining land use for the Energy Mine was 80 percent rangeland and 20 percent cropland, and reclamation is oriented to these uses.

### Factors Affecting Reclamation

1. MAP: 24 in.; MAT: Estimated at 40° F; frost-free growing period is about 57 days.
2. Physiography: Hilly with slopes 10 to 30 percent in reclamation area; elevation is about 7200 ft.

3. Soil: Loamy with thick dark A horizons, over 3 ft thick and excellent topsoil. The topsoil is removed in one lift and spread 12 to 18 in. thick over the shaped spoil.

4. Vegetation: Kuchler shrub-steppe with dominant species of mountain big sagebrush with a rich stand of Idaho fescue, wheatgrasses, forbs, and shrub species such as rose and snowberry.

Reclamation potential is good, with the major problem being suitable reclamation equipment; this includes a seed harvester for native mountain brome seed and an improved mechanical tub tree planter.

The company reclamation program is successful. The reclamation specialist is certainly the most competent of all specialists contacted during the project and is very professional.

## Reclamation Practices, Sequence, and Timing

1. Rough regrading of spoil: Accomplished by bulldozers.
2. Final grading: With a large blade.
3. Topsoiling: Accomplished in one lift with large scrapers.
4. Topsoil: Graded and smoothed with a road grader.
5. Seedbed: Chiseled, disced, and a mulch crop seeded.
6. Contour furrowing: Accomplished with a blade being raised and lowered at intervals producing dikes in furrow.
7. Seed mixture: Planted in winter grain stubble in the fall.
8. Trees and shrubs: Transplanted with a front-end loader. Snowberry is planted from tubed or bare rooted stock, and trees and shrubs are planted throughout the year when snow cover is absent.

Practices not used: Gouging, irrigation, terraces, and basins.

The contour furrow appears to be a successful practice which controls surface runoff and sedimentation. It should be adapted as standard practice for mined-land reclamation in this resource area. Young native tree planting with front-end loaders is successful. Another good practice is building rock piles for small mammal and bird habitats. Harvesting mountain brome seed is unique and a good idea for the higher moisture areas such as here and at Colstrip, Montana. Seed is not available commercially.

It is recommended that topsoil should be removed in two lifts. The first lift should be the A horizon; second lift the B horizon or equivalent to utilize the total soil depth above overburden.

## PHYSICAL AND RECLAMATION DATA

This section gives information concerning the strip coal mines visited in this project. Much of the general information was obtained from Keystone Coal Industry Manual. Other detailed information was gathered through a set inquiry procedure at the time of the visit to the mines and through personal contacts with BLM personnel.

Indian Head Coal Mine; Beulah, North Dakota; Mercer County; Joe D. Mitzel, Superintendent; J. Brown and Terry Brown, Reclamation; Jerry Becker, Pit Director. Mine reclamation program review and data collection were made by M. A. Fosberg and Jack Chugg. Valuable assistance was given by Fred Sandoval, SEA, on making contact and showing research results. Fred Waldhaus, BLM S.O., Billings, Montana, and Jerry Pitman, BLM D.O., Dickinson, North Dakota, reviewed the program.

### General Site Data

Location map: North Dakota surface-minerals management map, Hebron, SW-3, 1975.

Major land resource area: F 54.

Climatic condition: MAP, 15 in.; MAT, 40° to 46° F.

Physiography: Gently undulating to steep glacial till and sedimentary uplands with slopes ranging from 3 to over 30 percent.

Elevation: 1790 ft.

Geology: Lignite deposits associated with Sentinel Butte and Tongue River Formations of Fort Union Group.

Average overburden thickness: 10 to 12 ft.

### Physical Profile

General Information:

Ash: Not utilized.

Premining land use: Native rangeland and cultivated pasture.

Cultural resources: Surveyed and cleared.

Visual resources and landscape plan: Developed and used as guide for shaping postmining landscape.

Wildlife inventory: Not completed prior to mining. Thirty head of mule deer frequent old unreclaimed mine spoils. Waterfowl use all ponds regardless of salinity. Old spoils have good cover of shrubs, trees, and grass for wildlife, the result of natural revegetation.

Paleontology: Inventoried and cleared.

Soil inventory: Made at a scale of 1"=400', a first-order soil survey. Soil textural class ranges from silty clay loams to sandy loams, and soil depth to overburden is variable.

Overburden: Samples, analyses, and characteristics are well documented.

Vegetation inventory: Made prior to mining.

Trace elements, salts, and heavy metals: Identified from soil and overburden laboratory analyses.

Water quality of surface water: Studied. Iron staining occurs in all water ponds due to high sodium influence. Numerous ponds in spoils area exist where there was no water in premine condition.

Sediment characteristics of soils and overburden: Not studied in premining stage. State Geological Survey and SEA have been making studies on sediment yield and water-quality runoff in reclaimed areas.

Reclamation Description:

General: Vegetation seed mix used not standard but includes: alfalfa (Medicago sativa), sweetclover (Melilotus), crested wheatgrass (Agropyron cristatum), slender wheatgrass (Agropyron trachycarlum), western wheatgrass (Agropyron smithii), smooth bromegrass (Bromus inermis), intermediate wheatgrass (Agropyron intermedium), pubescent wheatgrass (Agropyron trichophorum), sideoats grama (Bouteloua curtipendula), and little bluestem (Andropogon scoparius). Postmining vegetation production monitored. Revegetation stipulations stated in reclamation plan and are on file. Reclamation costs per acre: $3,000 to $4,000.

Area disturbed and reclaimed by mine:

Total acres disturbed: 2700 A
Reclaimed to date: 1500 A
Reclaimed per year: 60 to 80 A
Disturbed per year: 60 to 80 A
Total area to be disturbed during life of mine: 3700 A

Practices and timing used in reclamation:

1. Spoils: Graded and shaped to nearly the original contour.
2. Topsoiling: Prior to soil removal, area staked on a 100-ft grid with markers showing depth of top soil to be removed in two lifts, A horizon first, then B horizon. Lifts stockpiled in separate piles and replaced in reverse order. Total soil profile plus part of C horizon removed as part of second lift.
3. Seedbed preparation area: Leveled, mulched, crimped, and harrowed prior to seeding.
4. Mulching: Used.
5. Ripping: Used only in wintertime removal of topsoil and subsoil.
6. Discing: Used.
7. Gouging: Not used. It was tried experimentally by Montana State University but was determined to be unsuitable practice.

8. Basins: Not used. Tried experimentally and determined to be unsuitable.

9. Terraces: Not used. Tried experimentally and failed.

10. Catchment basins: Being constructed. Will be used for water storage in reclamation and later as waterfowl area.

11. Timing sequence for reclamation practices:

a. Topsoil: Removed in two lifts and stockpiled with scraper.

b. Spoil piles: Reshaped with use of bulldozer. Scrapers must be used to shape drainage.

c. Topsoiling: Done by returning soil in reverse sequence as removed.

d. Seedbed: Prepared by chiseling, discing, mulching, and harrowing prior to seeding.

e. Seed mixture: Drilled in the spring or fall, depending upon soil moisture. Late fall seeding preferred when moisture conditions are suitable.

12. Irrigation: Not used or needed.

13. Species planted in seed mixture are: Sweet clover; smooth brome; western, intermediate, and pubescent wheatgrass; sideoats grama; and little bluestem.

14. Trees: Not transplanted. If tree planter were available, some trees would be transplanted on experimental basis. Seedling shelterbelts are being planted.

15. Shrubs: Not transplanted, but if planter were available, shrubs would be planted on experimental basis.

16. Fertilizers: Not generally used. Experimental plots show responses to N and P.

17. Amendments: Used on experimental basis. Gypsum applications showed some response where topsoil was thin (<2 in. thick) over the shaped spoil.

18. Trace elements: Not used.

19. Protection: Given to reclaimed areas by fencing.

20. Management techniques, such as grazing: Not used or allowed by North Dakota Public Service Commission unless land reclaimed to grassland.

21. Water: Harvested only for dust control, utilized heavily by waterfowl in ponded areas.

Equipment used in reclamation included: 637 Caterpillar scrapers; 41-B track Fiat Allis, 455 Kamatsu track, and 834 rubber tire dozers; 4020 John Deere and WD-45 Allis Chalmers tractors; disc; chisel; plow; drills; harrow; weed sprayer; water or fuel truck; and rock picker.

Equipment needs: Tree transplanter.

Reclamation: Conducted by Indian Head Mine personnel.

Reclamation problems identified are as follows:

1. Piping through topsoil and overburden: Common due to high sodium content and settling of clays in overburden.

2. Differential settling (subsidence) of topsoil and overburden: Occurs in all areas due to settling of clays and high

sodium content. This changes reshaped surface resulting in water ponding or excess surface runoff.

3. Capillary rise of salts into topsoil results: Problem because of effect on vegetative growth.

4. Erosion and soil dispersion: Problem where salts are high near surface.

There are no offsite technological problems such as handling of ash; sediment control may be a problem.

Water consumption for dust control comes from ponds; water is used by waterfowl.

Monitoring of postmining reclamation:

1. Agency doing monitoring: North Dakota Public Service Commission.
2. Number of surface-water stations: At 8 discharge locations on mine.
3. Number of ground-water wells used: None.
4. No aquifers disrupted.
5. Air-quality station: Not required for mine.
6. Weather station: Operated at plots by Northern Great Plains Research Station (SEA).
7. Soil: Checked and sampled by company.
8. Vegetation: Not monitored by permanent transects.
9. Trace elements: Not monitored.
10. Comparison areas: Not used.
11. Wildlife: Not studied for change in numbers, kinds, etc.
12. Fish: Not present in area.
13. Sediment control: Studied in one structural basin.

Company concerns: This company thinks it is overregulated; however, they did not specify regulations that give them the most problems.

Rosebud Coal Mine; Colstrip, Montana; Rosebud County; Tim Wood, Mining Supervisor; Chris Cull, Earl Murray, Dick Bassett, and Pete Mellbom, Reclamation Specialists.

Mine reclamation program review and data collection were made by M. A. Fosberg with company Reclamation Specialist Jackie Hanson. Fred Walhaus made arrangements and participated in mine review. The mine was visited where tree planting trials and fertilized treatments on alfalfa-grass reclamation stands were observed.

## General Site Data

Location map: Montana surface-minerals management map, Colstrip, SE-21, 1974.

Major land resource area: G 58.

Climatic conditions: MAP, 15.5 in.; MAT, estimated 42° to 45° F.

Physiography: Undulating to hilly uplands with 5 to over 30 percent slopes.

Elevation: 3400 ft.

Geology: Subbituminous coal comes from Rosebud seam about 23 ft in thickness.

Average overburden thickness: 20-150 ft; 80 ft is approximate average.

## Physical Profile

General Information:

Ash: Not utilized.

Premining land use: Dominantly native range with small amounts of cropland.

Cultural resource survey: Completed in premine permit process. Petroglyphs and similar sites which occur within mining property are mitigated or otherwise protected.

Postmine topography and reclamation plans: Approved before permits issued. Specific reclamation practices decided in timely manner.

Wildlife inventory: Made by consultants and monitored.

Paleontology: Investigated. Finding of fossil bones reported as they are encountered.

Soil inventory: Made at scale of 1:400, used to determine thickness of topsoil removal. Soil sampled and analyzed at 1350-ft intervals at test sites for overburden. Soil texture classes range from sandy loam to clay loam. Depth of suitable topsoil averages about 2.5 ft.

Overburden: Sampled and analyzed at 1350-ft intervals. Composite samples collected through each 5-ft vertical interval through second (McKay) coal seam.

Native vegetation: Analyzed for productivity, species present, percent composition, ground cover and stocking rates.

Trace elements: Identified in soil and overburden analysis.
Water quality and quantity of surface and ground water: Determined.
Sediment yields of premining conditions: Being determined for new permit areas.

Reclamation Description:

General

1. Vegetation seed mix: Predominantly native species with some introduced species.
   a. Winter graze seeded with seed mix as cover crop to provide temporary stabilization.
   b. Seven mixtures used for different slope aspects. Mixtures change due to seed availability at that particular time.
   c. Mixture approved by regulatory authority (Dept. of State Lands).
2. Stipulations in reclamation plan: Give specifications for seed mix and grading.
3. Reclamation costs per acre: $9,000 to $11,000. This includes regrading through seeding, fertilization, fencing, and monitoring after reclamation completed. On per-ton basis, reclamation costs are between $0.40 and $0.50.

Area disturbed and reclaimed by mine:

1. Total area disturbed to date: 3300 A
2. Revegetated to date: 1200 A
3. Revegetated per year: Average 300 A planned for 1978 and 1979.
4. Disturbed per year: 300 A
5. Total area to be disturbed in life of mine: 25,000 A

(Above figures do not include original mining done by Northern Pacific which started in 1924. Some reclamation of original mine spoils is contemplated by Western Energy. Burlington Northern regraded and replanted approximately 1000 A from 1970 to 1974.)

Practices used in reclamation and their cost, if available:

1. Grading and shaping of spoil: Costs (slope and aspect according to plan) $5,000 to $9,000/A. Headwalls reduced to a 5 to 1 slope or less.
2. Topsoiling: Done in two lifts. Costs are $1000/A (2-1/2 to 3 ft used and put down in two lifts with approximately 6 in. of original surface taken in first lift.)
3. Seedbed preparation: (See 11 below.)
4. Mulching: Straw used on slopes <7 to 1, and hydromulch used on slopes >7 to 1.
5. Ripping or chiseling: Done on all slopes prior to seeding.

6. Discing of straw mulch: Rotavated into soil.
7. Gouging: Sometimes used on slopes 7:1 and steeper.
8. Basins: Not permitted by state regulations if exceed 1.0 cu. yd.
9. Terraces: Not used.
10. Sodding: With native sod in reconstructed drainageways costs about $2,000/A.
11. Timing sequence for reclamation practices:
a. Spoil shaped and regraded by bulldozers.
b. Soil stripped by scrapers in two lifts and placed on spoil regraded surface in one operation if time permits.
c. Reclamation sequence after topsoiling completed: 1) (Slopes <7:1) chiseled, straw mulched (1-1/2 to 2 tons/A), fertilized (175 lbs/A 11-55-0 or 18-46-0) rotavated, planted, and cultipacked. 2) (Slopes >7:1) chiseled or disced and sometimes gouged, planted, packed, hydromulched with wood fiber. These procedures based on State regulations.
12. Irrigation: Not used. Experimental study will begin in spring of 1979 to determine feasibility of irrigation.
13. Species planted: (See pages 51 through 53.)
14. Equipment used in reclamation: D8 and 631 Caterpillar; D9 Dozers; Terex T-24 scrapers; Finn hydroseeder; IH 504, Ford 5000, and Ford 9700 farm tractors; 10' chisel plow; 12' disc; 12' rangeland drill; 12' Brillion seeder; modified gouger/seeder; cyclone broadcaster; 9' sickle bar mower; Vermeer tree spade; Giddings soil sampler; Sheepsfoot cultipacker; Sunflower cultipacker; rotavator; modified stakprocessor; and a modified manure spreader.

Reclamation procedure used is as follows:

1. Spoil regraded to contour and topsoil redistributed. Sample regraded spoils and topsoil on five-, three-, and two-acre grid in Areas A, B, and E, respectively. Samples will be analyzed according to current guidelines.
2. Replaced topsoil chiseled on contour. Chiseled area fertilized with monoammonium phosphate using broadcaster. Fertilizer applied to provide approximately 14 lbs of available N and 30 lbs of available P per acre. Final seedbed preparation consists of either rotavating or discing surface to 4 in. On slopes with gradients between 10 to 1 and 7 to 1, 3000 to 4000 lbs of wheat straw or native grass hay is applied per acre following chisel runs. Straw or hay is applied with modified manure spreader or stakprocessor. Both straw and fertilizer are incorporated into soil at 4-to-6-in. depth with rotavator.
3. Reconstructing Postmine Management Units, described on pages 48 and 49, over period of 1 to 3 years. Transplanting and interseeding tree, shrub, and forb species for use by both wildlife and domestic livestock will occur then.
4. Establishing permanent grassland seeding mixtures will be delayed from 1 to 2 years so that properly establishing trees, shrubs, and forbs can take place without competition from aggressive native grass species. During this period, winter graze will be seeded as soil stabilizer at rate of 5-10 lbs/A PLS.

5. Permanent grass mixtures will be seeded with Brillion seeder into winter graze stubble. Surface Seedbed Scarifier will be used to loosen soil for planting while causing minimal disturbance to native plant species that have germinated and established themselves from redistributed topsoil.

6. Seeding rates for grassland mixes will be 20 lbs/A PLS, which will provide adequate space for encroachment of native species from undisturbed sites nearby. There will also be supplemental mixture that will be broadcast with Cyclone broadcaster prior to seeding with Brillion. Mixture will be broadcast on all Management Units except the Wetland/Riparian Zone. This will be mixture of native indigenous plants that have a lot of pubescence or long awns that make them hard to seed through box-type drill. Many of these species will come from seed collected locally and mixed to insure proper PLS levels.

7. Seeding periods will be primarily fall (late August to late September) and late fall (after October 15th). Spring seeding will occur only if weather and field conditions warrant and chances of successful seed emergence and establishment seem inevitable.

8. Where conditions warrant, slopes with greater than a 7:1 gradient will be gouged and seeded with modified gouger/seeder. Gouging will be done along contour following incorporation of fertilizer.

9. On slopes 7:1 or greater slopes, wood fiber will be applied at 2000 lbs/A as hydromulch using hydroseeder.

10. Selected reaches along bottoms of reconstructed drainages will be sodded for erosion control and as source of native seeds. To greatest possible extent, native sod will be transplanted from premine drainages.

11. Trees transplanted: Ponderosa pine (Pinus ponderosa) and juniper (Juniperus) on some slopes. Chokecherry, hawthorn (Crataegus), currant (Ribes), and wild plum (Prunus) transplanted into drainages. Green ash (Fraxinus pennsylvanica), willow (Salix), and cottonwood (Populus spp.) also transplanted with tree spade.

12. Shrubs transplanted: Rabbitbrush (Chrysothamnus), rose, buffaloberry (Sheperdia canadensis), fourwing saltbush, blue elderberry (Sambucus caerulea), skunkbush sumac (Rhus trilobata), gooseberry (Ribes), and sagebrush (Artemisia).

13. Fertilizer used first year: 175 lbs of 18-46- or 11-55-0, as determined by soil analysis.

14. Amendments: Not used.

15. Protection measures: All revegetated areas fenced.

16. Management techniques: Limited controlled grazing requires regulatory authority approval. It has been found by Defuit's research that it is beneficial practice. Grazing will be allowed in 1979 as extension of earlier research.

17. Water harvest: Used only for hydroseeding and dust control. Finding sufficient water can be problem in area.

Equipment used: John Deere rangeland drill, chisel plow, dozers, scrapers, Sheepsfoot and Sunflower cultipackers,

hydroseeder, Hodder gouger, rotavator, Brillion seeder, Vermeer tree spade, 3 tractors, straw spreaders, sprayer, broadcast seeder.

Equipment needs: Not identified.

Reclamation: Conducted by the Chris Cull Company, reclamation specialists in surface-mined land.

Reclamation problems: Primarily erosion and surface-water control. Depressions other than nonpermanent sedimentation ponds for water accumulation permitted by Montana State law. This is considered to be too restrictive when it is known that there are no contaminants in soil or spoil. It would be practical, without additional cost, to put in ponds for water control to be used for livestock water and wildlife habitat. This water could also be used in reclamation for hydroseeding and dust control. A real problem is not having enough water for these uses.

Offsite technical problems such as ash disposal: No problems of this type.

Water consumption: For hydromulching and dust control. Source of water used predominately spring snowmelt and rainfall runoff. Occasionally pit will have ground water pumped from it.

Monitoring postmine reclamation:

1. Agency and department in charge: State and the company.
2. Number of surface-water stations: 8.
3. Ground-water wells: 100-150 wells distributed over Rosebud and McKay Formations.
4. Aquifers disrupted: Shallow ground-water system comprised on disjointed coal and overburden "aquifers" with low transmissivites.
5. Air-quality stations: Six high volume stations monitored for 24 hours every 6th day with 8 dustfull jars analyzed once a month.
6. Weather station measurements: Taken from one station (precipitation and temperature) operated by the company. One station with automatic remote monitoring equipment operated by MSU.
7. Soil for topsoil suitability and regraded spoil: Analyzed after topsoiling is completed. Company watches for vegetation failures.
8. Vegetation on reclaimed area: Monitored by permanent established transects.
9. Some trace elements: Not monitored by plant uptake.
10. Comparison areas offsite: Established by vegetation type.
11. Wildlife monitoring: Done by ecological consultants.
12. Fishery changes: Does not apply.
13. Sediment control structure or ponds: Used. No discharge is presently permitted.

## Company Concerns on Reclamation.
## (Needs for Future Research at the Rosebud Mine)

Although much progress has been made toward achieving reclamation goals in 11 years of research, many problems remain to be solved.

In the revegetation area, work should be continued on plant materials selection, with particular emphasis on designing mixtures composed of mutually compatible species. Fertilization needs of native species on spoils topsoiled with the current two-lift application method remain to be assessed. Additional research on tree and shrub reestablishment on mined lands is required, with emphasis on special seeding and/or transplantation methods. Variable times seeding strategies should by developed which will be flexible enough to adapt to the striking year-to-year fluctuations in weather patterns characteristic of the Colstrip area.

Revegetation areas will be divided into Postmine Management Units as described below. Each management unit will represent a particular plant community type, or combination of types, that exists in the area prior to mining. These plant community types are documented in the premine vegetative surveys that were conducted by ECON INC. of Helena, Montana.

Grassland seed mixtures will be formulated to include those species occurring naturally in the premine vegetation surveys, as represented in each Postmine Management Unit. Tree and shrub species will conform to the same code and will be reestablished with Vermeer tree spade use, in conjunction with various seeding and propagation techniques currently being researched in the field of postmine revegetation techniques, both at the Rosebud Mine and on other Northern Great Plains mine sites.

Seeding mixtures and indigenous species selected for transplanting in the Postmine Management Units are included on pages 51 through 53.

The Postmine Management Units are as follows:

Wetland/Riparian - Small zonal areas confined to the lower stretches of reconstructed drainages and around water impoundments. Species selected for revegetation will be adapted to high moisture sites and will include those varieties that represent quality wildlife habitat.

Lowland/Drainage - Reconstructed drainages and lowland run-in sites that will return to the same state as existed prior to mining. These are ephemeral drainage areas receiving excess precipitation runoff from surrounding sites, thus effectively increasing soil moisture content. These areas will contain stabilizing grass, shrub, and tree species that will provide food and cover for both wildlife and domestic livestock.

Uplands - Areas that occur on level, nearly level and moderate slopes. This is a major grassland type that is interspersed with various shrub associations, providing food for both wildlife and domestic livestock.

Steep Uplands - Areas that occur on slopes of 10:1 or greater. These are also grassland types, mixed with open stands of conifers and various shrub associations. These areas contain food and cover for both wildlife and domestic livestock.

Conifer Zones - Areas located at the summit of reconstructed hilltops. These areas will be characterized by conifer/shrub vegetation complexes. This unit is associated primarily with wildlife habitat and will serve to provide food and cover for various wildlife species.

A definite need exists for developing coordinated, comprehensive postmining land-use planning in designing the revegetation of an entire mine site. Such planning would be beneficial in terms of logically arranging types of reestablished plant communities on mined lands in light of anticipated postmining land use. For example, variable sized and arranged portions of a given mine unit could be revegetated to native range, improved pasture, critical wildlife habitat and/or cropland to fit in logically with surrounding land and land uses.

As noted previously, the importance of proper management to developing revegetated mined lands prior to bond release has become apparent. It is thus critical to continue and expand current research activities on grazing, burning, and mowing as management methods. Additional methods should be developed, such as the proper, judicious use of herbicides in certain critical situations.

Presently great uncertainty exists on what constitutes toxic concentrations of certain salts and trace elements in overburden and soil on mined lands at Colstrip and elsewhere. Research will be required to indicate what actual levels of such elements in soil and spoil do indeed constitute a threat to hydrologic systems, plant growth, and forage quality. As a corollary to this, a need exists to assess plant forage quality on mined lands as a function of topsoil and overburden characteristics. Although some research on these topics has been initiated at Colstrip and other locations, more effort is needed.

Dave Johnston Coal Mine; Glenrock, Wyoming; Converse County; Larry Tehaka, Superintendent; Neil Harrington, Reclamation Director. Mine reclamation program review and data collection were made by M. A. Fosberg with Company Reclamation Specialist Neil Harrington. BLM personnel at the Casper office made arrangements and participated in mine reclamation review.

## General Site Data

Location map: Wyoming surface-minerals management quad, Cole Creek, NE-27, 1974.

Major land resource area: G 67.

Climatic conditions: MAP, 10 in.; MAT, 45° to 50° F.

Physiography: Undulating to hilly sedimentary uplands with average slopes of 6 to 12 percent.

Elevation: 5200 to 5400 ft.

Geology: Subbituminous coal comes from the Fort Union Formation, the Badger seam, 17 to 20 ft thick. School seam, 30 to 36 ft thick, is also mined.

Average overburden thickness: 20 to 140 ft.

## Physical Profile

General Information:

Ash: Not presently used. Past use caused problems because it worked to surface.

Premining land use: Rangeland with plant communities of Wyoming big sagebrush.

Cultural resources: Studied by State of Wyoming. Several tepee rings found and cleared.

Visual resources: Not recorded in landscape plan. Natural landscape visually determined prior to mine cut.

Wildlife studies: In progress by company. Present deer and antelope populations thicker on reclaimed land than adjacent lands. Last year deer herd numbered 200, but due to severe winter and spring, less than 100 remain.

Paleonology: Studied by State of Wyoming.

Soil inventory: Completed. Soil survey not considered to be useful because soils too variable for scale used (scale was not known).

Overburden: Originally sampled at 1-mi intervals. Bureau of Mines presently doing investigation in greater detail.

Vegetation prior to mining: Investigated by University of Wyoming and USFS. They established permanent enclosures and transect.

Trace elements studies: Made and showed no problems with excessive trace elements or heavy metals.

Water-quality analyses: Made on many water samples from wells, surface basins, pits and puddles.

Sediment loss and erosion studies: Made. Reservoir below mine used to check sediment load in runoff.

Reclamation Description:

General

1. Vegetation seeding done with following seed mix: Five lbs of fairway crested wheatgrass, 5 lbs of thickspike wheatgrass and fourwinged saltbush. Fourwinged saltbush is broadcast and grass seed is drilled.
2. Stipulations in reclamation plan: Calls for millet to be planted as mulch crop in spring and seed mix seeded in this mulch in fall.
3. Cost per acre for reclamation: Estimated from $3000 to $6000.

Area disturbed and reclaimed by mine:

1. Total area disturbed to date: 1402 A
2. Reclaimed to date: 1100 A
3. Reclaimed per year: 80 A
4. Disturbed per year: 75 A
5. Total area to be disturbed during life of mine: 4500 A

Practices and timing used in reclamation and their cost, if available:

1. Grading and shaping: Done with slopes of <3 to 1.
2. Topsoiling: Uses all soil profile in one lift. Soils are mainly sand to sandy loams. Generally thickness of soil is <18 in. Soil graded to provide minimum of 6 in. of topsoil over spoils for seedbed. Spoil left rough prior to topsoiling; therefore, much of it is over 6 in.
3. Seedbed preparation: (See 10.)
4. Mulch: Grown with millet use; more satisfactory than straw because of weed seeds and also provides food for birds.
5. Ripping: Used in shaped spoil which is ripped on contour to 4 ft.
6. Discing: Not used.
7. Basins: Not used.
8. Chisel plow: Main implement used.
9. Timing sequence for reclamation practices:
   a. Topsoil stripped by scrapers.
   b. Overburden stripped and piled.
   c. Spoil reshaped by bulldozers.
   d. Deep ripping on contour.
   e. Topsoiling to approximately 6 in.
   f. Chisel plowed.
   g. Millet seeded in spring.
   h. Seed mix seeded in fall.
10. Irrigation: Not used.

11. Species planted: (See General Reclamation Description, No. 1.)

12. Trees: Tried only on experimental plots.

13. Shrubs: Not transplanted.

14. Fertilizer: Not used. Fertilizer plots this year using 20 lbs showed beneficial effects. Probably 10 lbs/A would be beneficial application in normal year. Mandan Research Station found fertilizer not usually beneficial on rainfall area under 12 in.

15. Amendments: Not used.

16. Trace elements: Not used.

17. Protection measures used: Fences for revegetation protection and high walls graded to a 5-to-1 slope.

18. Management techniques: Not used such as grazing on water developments. Previous grazing study showed that stands thickened gains were double over native range.

19. Water: Not developed or harvested; there are no streams in area.

Equipment used includes the following: Ford 4600 wheel tractor; Case log skidder, 4-wheel drive; D9 and Fiat Allis 31 dozer with ripper; John Deere drill with 8 in. spacings and press wheel; 637 cat and .339 F Wabco scrapers; and eight-wheel dozer.

Equipment needs: Not specified.

Reclamation work: Conducted by company personnel.

Reclamation problems: Caused by lack of regulatory coordination according to new Reclamation Director Don Hartley. "Reclamation manager needs own permanent help for a systematic and efficient reclamation program" was the opinion of Neil Harrington, Reclamation Director at time of interview.

Offsite technical problems: Not identified.

Water consumption: Used only for dust control. About 5000 gal. are used daily; no irrigation is used.

Monitoring postmine reclamation:

1. Monitoring: Conducted by the company.

2. Surface water: Monitored by 20 to 30 wells and pits.

3. Ground water: Studied from several wells.

4. Aquifers: Not disrupted.

5. Air quality: Studied 4 times per year. No serious dust problem has been reported.

6. Weather data: Collected by complete weather station at EPA plots and second station monitored with remote sensing devices by MSU. Precipitation is approximately 10 in.

7. Soil: Not monitored. No problems with compaction due to high sand in soils. Plots that studied NPK, pH and salts show that they are not a problem.

8. Vegetation: Measured, in part, by University of Wyoming and FS. Portland Office will do this in future with consultants.

9. Trace elements: Monitored by Colorado School of Mines.

10. Offsite comparison areas and reclamation plot sites: Established.

11. Wildlife changes: Made only by observation.

12. Fish: Not on site.
13. Sediment control structures: Established. New rules and regulations require them.

Companies' concerns with reclamation, regulation, or stipulations: "State of the art" for mined-land reclamation is presently being "forced" by regulation. Regulations are being enforced that may or may not withstand the test of time. Ideas that seem good now may, in retrospect, appear foolhardy later. Two things should be kept in mind while performing the regulations' functions, and they are:

1. The economical consequence of each of their decisions currently being made concerning energy development.

2. Surface-mining regulation currently undergoing many changes. Mining companies and regulators must maintain a spirit of cooperation if the goal of minimizing enviromental effect of mining is to be reached while maintaining the necessary energy production for the consumer at a cost society can pay.

Seminoe Coal Mine #1; Hanna, Wyoming; Carbon County; Dave Kieper, Superintendent; Greg Bierei and Fred Newman, Reclamation Specialists. Mine reclamation program review and data collection were made by M. A. Fosberg with Company Reclamation Specialists Greg Bierei and Fred Newman and Resident Engineer Steve Montone. BLM personnel at the Rawlins Office made arrangements and participated in reclamation review.

## General Site Data

Location map: Wyoming surface-minerals management quad SE-14, 1974, of Hanna Basin.

Major land resource area: D 34.

Climatic conditions: MAP, 11 in.; MAT, 40° to 42° F.

Physiology: Undulating and hilly sedimentary uplands.

Elevation: 7000 to 7300 ft.

Geology: Subbituminous A and C and coal occurs in the Ferris Formation made up largely of sandstone, siltstone, and shale.

Average overburden thickness: Not recorded.

## Physical Profile

General Information:

Ash: Not used.

Premining land use: Native rangeland in Wyoming big sagebrush plant associations including western wheatgrass and needleandthread.

Cultural resources: Researched by the State of Wyoming.

Visual resources inventory in form of landscape plan: Not made. Physical setting for postmined landscape developed as mining proceeds.

Wildlife resources for big game animals: Not inventoried but listing of nongame animals and birds was made prior to mining.

Paleontology: Investigated by State during premining planning.

Soil inventory includes: Old SCS soil survey and newer survey made by mine reclamation consultant from Denver. Soils textural class is sandy loam and depth of soil to overburden is not noted.

Overburden study: Done by company.

Vegetation inventory: Not conducted originally. Present study being made by company to determine potential vegetation production, which includes native species list and percent cover.

Trace elements study: Made on soils and overburden. No toxic problems encountered.

Water study to determine quality and quantity: Presently being conducted by company.

Sediment potential for soils: Determined only from literature review.

Reclamation Description:

General

1. Vegetation for postmining is seed mix (with percentages) of: Crested wheatgrass, 10; thickspike wheatgrass, 23; slender wheatgrass, 18; Indian ricegrass (Oryzopsis hymenoides), 5; yellow sweetclover, 10; and fourwing saltbush, 10. (Pounds planted per acre: 15.)
2. Seed mix: Stipulated in reclamation plan.
3. Cost per acre for reclamation: $3,000 to $10,000 under old rules. Cost under new rules will rise because more acres will be used.

Area disturbed and reclaimed by mine:

Total area disturbed: Not noted.
Reclaimed to date: Not noted.
Reclaimed per year: 300 A
Disturbed per year: 300 A
Total area to be disturbed during life of mine: Not noted.

Practices used in reclamation and their costs if available:

1. Grading and shaping: Completed on 95 percent of area according to plan.
2. Topsoiling: Generally not noted and removed to underlying overburden. Topsoil stockpiled and later spread over the shaped spoil (not noted). Terrace ridges developed on all surfaces as standard practice. They are not noted. Surface bladed to make final spread of topsoil and form terrace ridges.
3. Seedbed preparation after shaping: None.
4. Mulching: Accomplished by growing annual grain crops. Seeding done in grain straw mulch.
5. Ripping: Not practiced.
6. Discing: Not practiced.
7. Gouging: Not practiced, but it has been done experimentally on some plots.
8. Basin development: Not permitted by State regulations.
9. Irrigation: Not practiced.
10. Large boulders: Set up for bird use.
11. Timing sequence of reclamation practices:
    a. Topsoil removed in one lift by scraper and stockpiled.
    b. Spoil is regarded and shaped by bulldozers. Topography is formed by visual inspection. Sixteen dozers are used by three crews five days per week.
    c. Topsoil is roughly spread from stockpile with scrapers and then uniformly spread by grader with blade.
    d. Terraces are made at time soil is being bladed.
    e. Annual grain is drilled in spring directly into the blade-graded soil.

f. Seed mix is drilled into the grain straw mulch in fall.

12. Irrigation: Not used.

13. Species planted: (See General Reclamation Description, No. 1.)

14. Trees: Not used because area too droughty.

15. Shrubs: Not transplanted, but fourwing saltbush used in seed mix.

16. Fertilizer: Not used because precipitation too low.

17. Amendments: Not used. No experiments have shown a need.

18. Trace elements: Not used.

19. Protection measures such as fences: Not installed because they are not required.

20. Trace elements: Not used.

21. Water development and harvest: Used for watering roads for dust control.

Equipment used: Bulldozers for grading, scrapers and front-end loaders for topsoil spreading, rangeland drill for seeding, and two Kamatozons 355 or 455 graders for spreading topsoil.

Equipment needed: Soil spreader with loader blade.

Reclamation work: Mainly accomplished by company personnel, but seeding contracted.

Reclamation problems are: Poor equipment and three seasons required to establish successful reclamation because of low natural moisture. Offsite technical problems were not identified.

Water consumption: Only for dust control.

Monitoring postmining reclamation:

1. Agency in charge of monitoring: Wyoming State Department of Environmental Quality.

2. Surface-water stations: Monitored by USGS.

3. Ground water: Monitored from five wells at Seminoe No. 2 by USGS.

4. Aquifiers: Not disrupted.

5. Air quality: Measured from two stations; there are no high volume stations.

6. Weather data collection station: Maintained by EPA.

7. Soil: Checked for thickness of suitable topsoil by State.

8. Vegetation yield plots on both reclamation and permanent native vegetation: Monitored by company.

9. Trace elements: No problem.

10. Comparison areas: Not used.

11. Wildlife: Not monitored.

12. Fish: Not present on site.

13. Sediment control structures: Constructed in three places. Normally erosion is not problem because of low precipitation.

Company concerns with reclamation: Not expressed.

San Juan Coal Mine; Farmington, New Mexico; San Juan County; Robert Allen, Superintendent or Mine Manager; Bill Teigs, Preparation Foreman; and Rodney Gebehart, Reclamation Specialist.

Mine reclamation program review and data collection were made by M. A. Fosberg with Company Reclamation Specialist Rodney Gebehart. Tim Kreager of the BLM office at Farmington made arrangements and discussed some of the needs in mined-land reclamation for that area of New Mexico. Bob Calkins, BLM District Manager, also discussed program.

## General Site Data

Location map: New Mexico, surface-minerals management quad, Farmington, NW-2, 1974, and Shiprock, NW-1, 1974.

Major land resource area: D 37.

Climatic conditions: MAP, 5 to 6 in.; MAT, approximately 50° F.

Physiography: Gently sloping to hilly uplands of sedimentary formation having slopes of 3 to 10 percent in mine areas.

Elevation: 5200 ft.

Geology: Subbituminous B and C coal occurs in the Fruitland Formation of the San Juan Basin part of southeastern and Colorado Plateau. Thickness of seam averages 16 ft.

Average-overburden thickness: Approximately 16 ft.

## Physical Profile

General Information:

Fly ash and bottom ash: Buried in pit below spoil.

Premining land use: Native vegetation dominated by shadscale, fourwing saltbush, and blue grama.

Cultural features, mainly Indian artifacts and wall paintings: Investigated. Five sites were excavated and cleared. Others present but will not be disturbed by mining operation.

Visual analyses landscape plan: Not developed. Topography evaluated as stripping progresses and landscape returned reasonably close to original shape. Box-cut slopes have maximum of 3 to 1 and remaining area 6-1/2 to 1.

Wildlife: Inventoried prior to mining.

Paleontology investigation: Not conducted.

Soil inventory: Conducted originally on small scale. New soil survey will be conducted on large scale for selected areas to be mined.

Overburden analyses: Made by New Mexico Land Company prior to Western Coal's ownership.

Vegetation: Studied and inventoried by Dr. Walter Gould, New Mexico State University.

Trace elements studies: Made which showed no heavy metal problems but did show sodium problem in overburden and soils.

Water analyses from ground water: Showed one part of mining area having high SAR of 35 to 40.

Sediment potential on premined lands: Not studied by company.

Reclamation Description:

General. Required that reclamation must stay within three spoil rows which must be seeded during following growing season:

1. Vegetation seed mix for postmining land use and reclamation is: Indian ricegrass, sand dropseed (Sporobolus cryptandrus), blue grama, yellow bluestem, streambank wheatgrass (Agropyron riparium), galleta, fourwing saltbush, shadscale, and winterfat (Eurotia).

2. Seed mix: As stated above and is stipulated in reclamation plan.

3. Cost per acre of reclamation, prior to OSM rules and regulations: $1,000 to $2,000. With newer regulations, cost will increase to $4,000 to $5,000/A. Increase attributed to new requirements for topsoil removal, soil analyses, regrading, fertilizing, and mulching.

Area disturbed and reclaimed:

Total area disturbed to date: 350 A
Reclaimed to date: 30 A
Reclaimed per year: 15 to 20 A
Disturbed per year (July 1, 1976, to July 1, 1977): 356 A
Total area to be disturbed during life of mine: Not noted.

Practices used in reclamation and their costs, if available:

1. Grading and shaping of spoil: Done by bulldozer based on visual approximation of preexisting topography.

2. Topsoil: Arbitrary at 8 to 12 in. In future, amount of topsoil removed and replaced will be total thickness of soil. This will be removed in one lift.

3. Spoil: Scarified by use of ripper after topsoiling. Done to break interface between topsoil and spoil which causes root retardation.

4. Mulch: Required at rate of 4000 lbs/A. Native bluestem straw from Kansas is used instead of regular grain straw because of high weed seed content.

5. Ripping: Used after topsoiling to scarify surface. This practice will be replaced by discing.

6. Discing: Will replace ripping for scarification.

7. Gouging: Only used on test plots, as benefits from gouging have not yet been decmonstrated.

8. Basins: Not permitted by OSM regulations. Not more than 1/4 yd of water permitted to stand in any one spot.

9. Terraces: Confined to one test plot for water harvest experiment.

10. Time sequence for reclamation practices: Topsoil stripped by scrapers and stockpiled. Bulldozer regrades spoil. Topsoil spread over shaped spoil. Fertilizer applied. Surface scarified. Seed drilled. Mulch spread and crimped. Area irrigated by sprinkler system.

11. Irrigation: Applied for 2 years. First year, 16 in. of water applied during growing season; second year, 8 in. of water applied.

12. Species planted in seed mix: Given in General Reclamation Description, No. 1.

13. Tree planting: Not practiced because area not adapted for tree growth.

14. Shrubs: Included in seed mix.

15. Fertilizer used: Eighty lbs of triple super phosphate and 60 lbs of N applied in one application.

16. Amendments: Not used. Gypsum and sulfur tried in research plots.

17. Trace elements: Not used.

18. Protection measures used: Fencing and high walls regraded.

19. Management techniques such as grazing: Not used. This would not be practical because of roads and equipment used for mine.

20. Water harvested: Comes from San Juan River after use by power plant; there is no local water from mine.

Equipment used: One HE31, one DS, one D-8, and one D5 bulldozer (to pull reclamation equipment); two 631 scrapers; one road grader; one rangeland drill; one Rhinco power mulcher; one Finn crimper; and one mulch trailer.

Equipment needs include: New Rome disc which is presently being purchased, a 36-in. disc that will not pull rock to surface.

Reclamation: Done by company using its own equipment and assigned personnel.

Reclamation problems: Lack of water and poor soil condition. Natural precipitation too low for good reclamation. Soils have high sodium and other salts, heavy clays and marine shells from overburden.

Offsite technical problems: Not identified.

Water consumption: Comes from San Juan River through power plant. First-year application is 16 in. and second is 8 in. Utah International contracted to strip and haul coal to plant; they use water daily for dust control.

Monitoring postmine reclamation:

1. Agencies involved: The company, New Mexico Pit Mining Commission, BLM, USGS, and OSM.

2. Surface water: Checked by USGS. One check station located on upper edge of lease and one on lower edge.

3. Ground water: Checked in 8 water wells by Public Service Commission.

4. Aquifers: Not present in coal seam being mined.
5. Air: Monitored at power plant.
6. Weather station data: Not noted.
7. Soil depth and soil analyses: Monitored by company after spread over shaped spoil.
8. Vegetation: Not presently monitored but will be in future.
9. Trace elements: Not monitored.
10. Comparison areas on offsite locations: Not established or monitored.
11. Wildlife changes: Not monitored.
12. Fisheries: Not affected.
13. Sediment control structures: Not present.

Company concerns with reclamation: Not expressed.

Edna Coal Mine; Oak Creek, Colorado; Routt County; Clarence Washburn, Mine Superintendent; Dave Scott, Reclamation Specialist; and Tony Meachum, Engineer. Mine reclamation program review and data collection were made by M. A. Fosberg with Josh Whetzel and Dave Scott, Company Reclamation Specialists, and Tony Meachum, Engineer. Lane Osborn of the BLM in Craig made arrangements with company and participated in review.

## General Site Data

Location map: Colorado surface-minerals management quad, Steamboat Springs, NW-10, 1974.

Major land resource area: E 48.

Climate conditions: MAP, 22 in.; MAT, estimated at 42° F.

Physiography: Hilly and low mountainous terrain with moderate to steeply sloping valleys--15 to 25 percent slope.

Elevation: 7200 to 7600 ft.

Geology: Yampa Coal Field includes Cretacean, Paleocene, and Eocene coal-bearing formations. They include lower part of Williams Fork Formation that constitute the Wolf Creek, Wadge and Sennox seams. The coal is 3/4 bituminous and 1/4 subbituminous.

Average overburden depth: Not noted.

## Physical Profile

General Information:

Ash: Not involved with mining or reclamation program.

Premining land use: Rangeland and wildlife.

Cultural resources: Not investigated.

Landscape plan: Not used. Landscape evaluation made as mining progresses.

Wildlife inventories: Conducted by BLM and DOW Division of Colorado Fish and Wildlife Department.

Paleontology investigations: Not known to have been completed.

Soil inventory used: Completed by SCS at relatively small scale.

Overburden studies: Conducted by company.

Vegetation analyses: Presently being conducted by company.

Trace elements: Studied and identified. There are no known problems.

Water studies (2): Done initially by CSU. New study is presently being initiated by company. They will conduct continuous monitoring.

Sediment or sediment potential: Had not been studied.

Reclamation Description:

General

1. Species list from which seed mix will be selected and rated are given following (attachment 1), page 38.
2. Seed mix stipulations are given in reclamation plan.
3. Reclamation costs range from $3,000 to $6,000 per acre.

Area disturbed and reclaimed by mine:

1. Total area disturbed: Not noted.
2. Reclaimed to date: Not noted.
3. Reclaimed per year: 82 A
4. Disturbed per year: 82 A
5. Total area to be disturbed: Not noted.

Practices and timing used in reclamation and their cost, if available:

1. Grading and shaping: Accomplished by bulldozers working spoil downslope.
2. Topsoiling: Accomplished by use of scraper in which total depth of soil is lifted in one lift and replaced in one operation. Topsoiling began in fall 1977.
3. Seedbed preparation: Top soil disced and fertilizer applied prior to drilling seed mix.
4. Mulching: Required by OSM. Straw mulch applied and crimped by discing.
5. Ripping: Not done.
6. Discing: Used prior to seeding.
7. Gouging: Used on steeper slopes.
8. Small basins: Developed during regrading to impound water for onsite retention.
9. Terraces: Not used.
10. Timing sequence for reclamation practices is:
    a. Remove topsoil.
    b. Strip overburden from coal seam.
    c. Remove coal seam.
    d. Regrade spoil.
    e. Topsoil (one operation).
    f. Scarified or disced on contour.
    g. Mulched with straw and crimped with disc.
    h. Reseed and fertilize areas with poor germination.
11. Irrigation: Not used.
12. Species planted: See General Reclamation Description, No. 1.
13. Trees and shrubs: Included in plan. Plan calls for using tubed plants with serviceberry (Amelanchier), snowberry, chokecherry (Prunus), and Gambel oak (Quercus gambelii).
14. Fertilizer: Used on spoils low in P. Current BLM trials show good benefits from use of P on spoils without topsoil and some benefits with topsoiled areas. No benefits shown from use of N.

15. Amendments: Not used.
16. Trace elements: Not used.
17. Protection planned: Fences for reclaimed areas.
18. Management techniques such as grazing: Not used.
19. Water harvest: Used only for dust control on roads.

Equipment used: Two 537 cat scrapers; one D9 cat, one 41B Fiat Allis, and one Kamatsu 355 dozer; one D10 cat on order; one Steiger tractor used to pull disc and seeder; and John Deere rangeland drill.

Equipment needed: Hydromulcher.

Reclamation work: Accomplished by the company.

Reclamation problems: Sediment control.

Offsite technical problems: Do not exist.

Water consumption: For dust control; no amount given.

Monitoring postmine reclamation:

1. Agencies involved are USGS, BLM, OSM, State Land Reclamation Board, and EPA on water.
2. Surface water: Monitored by EPA but details not known.
3. Ground water: Monitored by USGS; no details known.
4. Aquifer information: Not available.
5. Air quality: Not monitored in past. Company presently installing two air-monitoring stations.
6. Weather station data on precipitation and temperature: Collected by BLM. Company plans to install weather station.
7. Soil suitability: Checked by BLM and USGS.
8. Vegetation response measurements: Made by the company from Denver.
9. Trace elements: Not being monitored.
10. Comparison areas: Maintained by company under supervision of Dr. Whetzel in Denver.
11. Wildlife changes: Not monitored.
12. Fishery influences: Not monitored.
13. Sediment control monitoring: Not done. New OSM regulation calls for this but company has brought suit; therefore, nothing will be done until litigation settled.

Company concerns with reclamation: Not expressed.

Attachment 1: Edna Coal Mine

Vegetation types proposed to be used in revegetating mined land consists of grasses, legumes, shrubs and trees but are limited to those species listed below. Mixtures from the following species list will be selected for specific requirements. Priority will be given to those species with winter hardiness, palatability, protein value, and erosion control characteristics. Shrubs and trees will be selected on the basis of cover and browse characteristics.

GRASSES-LEGUMES

| Common Plant Name | Scientific Plant Name |
|---|---|
| Slender wheatgrass | Agropyron trachycaulum |
| Intermediate wheatgrass | Agropyron intermedium |
| Crested wheatgrass Nordan | Agropyron desertorum |
| Siberian wheatgrass | Agropyron sibiricum |
| Western wheatgrass | Agropyron smithii |
| Smooth brome | Bromus inermis |
| Mountain brome | Bromus marginatus |
| Hard fescue | Festuca ovina var. Durinscula |
| Arizona fescue | Festuca arizonica |
| Yellow sweetclover | Melilotus spp. |
| Cicer milkvetch | Astragalus cicer |

SHRUBS-TREES

| Common Plant Name | Scientific Plant Name |
|---|---|
| Snowberry | Symphoricarpos spp. |
| Winterfat | Euresta lanata |
| Serviceberry | Amelanchier alnifolia |
| Fourwing saltbush | Atriplex canescens |
| Antelope bitterbrush | Purshia tridentata |
| Rose | Rosa spp. |
| Gambel oak | Quercus gambelii |
| Aspen | Populus tremuloides |
| Chokecherry | Prunus virginiana |

Seed will be drilled into the prepared seedbed at the rate of 16 to 20 lbs of PLS per acre. Seeding rate per acre will vary per specific site condition. For example, south-facing slopes will receive higher seeding rates than a north slope. Tree and shrub species will be planted at a spacing of not less than 6 x 6 or 1200/A.

Seed availability estimates indicate that there will be sufficient quantities and variety selection to meet the proposed plan need.

Grasses and legumes will be seeded in the fall. Trees and shrubs will be planted in the spring, as soon as permitted by snowmelt.

Establishing diverse vegetation cover capable of regeneration and plant succession will be achieved by preparing a suitable seedbed using a Rome disc incorporating soil amendments as indicated by soils analyses.

Energy Fuel Mines 1 and 2; Steamboat Springs, Colorado; Routt County; William R. (Rick) Brown, Mine Superintendent; and Kent Croft, Range Scientist. Mine reclamation program review and data collection were made by M. A. Fosberg with Company Range Scientist Kent Croft. Lane Osborn of the BLM at Craig made arrangements with company and participated in reclamation review.

## General Site Data

Location map: Colorado surface-minerals management quad, Craig, NW-9, and Steamboat Springs, NW-10.

Major land resource areas: E 48.

Climatic conditions: MAP, 16.4 in.; MAT, 40° to 42° F.

Physiography: Hilly and low mountainous terrain with moderate to steeply sloping valleys, 15 to 20 percent slopes.

Elevation: 7000 ft; range is 6600 to 7400 ft.

Geology: Yampa Coal Field includes the Cretaceous and Tertiary coal-bearing formations. The major reserves are in the Williams Fork Formation that constitute the Wolf Creek, Wadge and Lennox seams. The coal is C bituminous coal with 10,900 btu, sulphur 0.4 percent, ash 8 percent, and moisture 10 percent. Average overburden thickness to coal seam is 90 ft with range of 60 to 110 ft.

## Physical Profile

General Information:

Ash: Not involved.

Premining land use: Eighty percent native rangeland and 20 percent cropland.

Cultural resources: Covered in EIS for northwest Colorado Coal. Studied by Colorado Historical Society, CSU, CU, and BLM.

Visual resources: Developed in terms of topographic contour maps for before and after reclamation.

Wildlife: Investigated in 1975 by Dames and Moore, consultants, who studied densities. This was followed by BLM Division of Wildlife investigations.

Paleontology: Investigated; fossils and shells were only identifiable materials.

Soil inventory: Completed by SCS. These are high intensity order two soil surveys. Soil texture ranged from silty clays to loams and soil depth to overburden was 6 to 60 in.

Extensive overburden analyses: Completed on federally leased lands and submitted to USGS.

Vegetation potential for native vegetation: Initially completed by SCS in conjunction with original soil survey. In 1975, Dames and Moore completed extensive baseline survey and BLM and Energy Fuels has added to this data in terms of production and composition. Potential native plant communities are mountain big

sagebrush, quaking aspen (Populus tremuloides), and other mountain shrubs.

Trace elements, including heavy minerals and metals: Identified following rules and regulations of EPA and USGS. CSU made baseline study of soils, vegetation, and trace minerals in area.

Water quality and quantity data: Collected by company technicians. ARS and USGS and Colorado School of Mines have done extensive studies.

Sediment potential studies: Not made because mining started prior to 1962 which was prior to reclamation laws. Currently, company is using universal soil loss equation (USLE) to determine potential sediment loss.

Reclamation Description:

General

1. Seed mixture used in postmining reclamation: Combinations of following depending on original native plant community.

Energy Coal Mine 1 and 2

SPECIES
Drilled October 1977

Grasses

| Common Plant Name | Scientific Plant Name | lbs/ac |
|---|---|---|
| Revenue slender wheatgrass | Agropyron trachycaulum | 2.000 |
| Oahe intermediate wheatgrass | Agropyron intermedium | 1.500 |
| Luna pubescent wheatgrass | Agropyron trichophorum | 1.500 |
| Lincoln smooth brome | Bromus inermis | 2.000 |
| Nordan desert wheatgrass | Agropyron desertorum | 0.250 |
| Sodar streambank wheatgrass | Agropyron riparium | 0.250 |
| Great basin wildrye | Elymus cinereus | 0.250 |
| Orchardgrass | Dactylis glomerata | 0.125 |
| Timothy | Phleum | 0.050 |
| Kentucky bluegrass | Poa pratensis | 0.020 |
| Durar hard fescue | Festuca ovina duriuscula | 0.125 |
| Barton western wheatgrass | Agropyron smithii | 0.250 |
| | Total grasses | 8.320 |

Forbs

| Common Plant Name | Scientific Plant Name | lbs/ac |
|---|---|---|
| Lutana cicer milkvetch | Astragalus cicer | 0.500 |
| Emerald crown vetch | Coronilla | 0.500 |
| Arrowleaf balsamroot | Balsamorhiza sagittata | 0.010 |
| Small burnet | Sanguisorba minor | 0.500 |
| Sweetanise | Osmorhiza occidentalis | 0.500 |
| Alfalfa | Medicago sativa | 0.250 |
| Rocky mountain penstemon | Penstemon strictus | 0.500 |
| Lewis flax | Linum lewisii | 0.500 |
| | Total forbs | 3.260 |

Shrubs

| Common Plant Name | Scientific Plant Name | lbs/A |
|---|---|---|
| Mountain big sagebrush | Artemisia tridentata vaseyana | 0.025 |
| Antelope bitterbrush | Purshia tridentata | 0.250 |
| Lanceleaf bitterbrush | Purshiua lanceolata | 0.250 |
| Chokecherry | Prunus | 0.250 |
| Serviceberry | Amelanchier | 0.250 |
| | Total shrubs | 1.025 |
| | Total mixture | 12.605 |

2. Seed mixtures: Stipulated in reclamation plan.
3. Cost per acre for reclamation: About $5,000.

Area disturbed and reclaimed:

1. Total area disturbed to end of 1979: 2316.93 A
2. Reclaimed to date: 1566.74 A
3. Reclaimed per year: 335.1 A
4. Disturbed per year: 353.49 A
5. Total area to be disturbed during life of mine: 4500 A

Practices used in reclamation and their cost, if available: (Costs are the most nebulous thing involved in whole program. For example, costs involved in mining and reclamation cannot be broken down quite as easily as most economists make it sound.)

1. Grading and shaping: Done by crawler bulldozer for rough initial grading and shaping. Final graded surface finished by large motorized road grader.
2. Topsoil: Removed in one lift to C horizon for mines 1 and 2. At mine 3, soil removed by horizon in two lifts. Large 45-yard scrapers lift and spread soil to a 12-to-18 in. thickness. Now all A and B horizons are removed separately. Soils are deep silt loams and loams.
3. Seedbed preparation after topsoiling: Bladed to smooth surface, chiseled, disced, and then drilled seed.
4. Mulching: Accomplished by seeding annual winter grain variety in spring or fall depending on conditions. Seed drilled into grain straw mulch in fall.
5. Ripping: With chisel plow after topsoil spread.
6. Discing: Prior to seeding.
7. Gouging: Not practiced because contour furrowing is far superior practice.
8. No basins made intentionally: OSM regulations do not permit basins for water collection.
9. Terraces: Not used.
10. Contour furrowing: Made with blade and tractor; considered satisfactory method for increasing water intake and sediment impondment.

11. Timing sequence for reclamation practices: Rough regrading with bulldozers, final grading with large blade, topsoil placed in one lift with large scrapers, topsoil graded and smoothed with road grader, chiseled, disced, drill seeded, and contour furrowed.

12. Irrigation: Not necessary.

13. Species mix: Listed and given under General Reclamation Description.

14. Trees and shrubs: Transplanted year-round with front-end loader. Aspen, serviceberry, oaks (Quercus), and chokecherry 10 to 15 ft tall used. Forty thousand trees will be planted on 35 acres in clumps and in massive rows in 1978 along with 9,000 snowberry plants in tubs and 31,000 as bare roots.

15. Shrubs: Planted along with tree transplanting and fertilized with N and K.

16. Fertilizing: Not routine practice. Soil analyses show N and P marginal according to tests, but further trials necessary on reclaimed areas. (BLM fertilizer trials in 1977, a very dry year, did not give response.)

17. Amendments: Not used.

18. Trace elements: Not used.

19. Protection measures to exclude livestock: Required by State and Federal regulations. There is damage from elk and marmots.

20. Management techniques such as grazing: Not permitted.

21. Water harvest: Used only for dust control. Only harvested water drains into mine pits.

Equipment used: Metal Master rangeland drill made at Merced, California; two Oliver rubber wheel tractors with 90 hp; one disc; one motor grader (Roy-go giant 24-foot blade); scraper (675B); D9, D10, TD25, Fiat-Allis 31-41's tractor dozers; and blade for making contour furrows.

Equipment needs: Shrub transplanter for tubed plants, a better front-end loader with greater bucket surface, and seed-harvesting equipment for harvesting local seed such as mountain brome (Bromus carinatus).

Reclamation work: Accomplished by company. Two Oliver tractors subcontracted.

Reclamation problems: Mainly legal but include lack of suitable equipment, such as mechanical tree planter and native seed harvester.

Offsite technical problems: Deal with regulation that do not really help reclamation.

Water consumption: Applied only to dust control coming from mine pit.

Monitoring postmine reclamation:

1. Agencies involved: Colorado Division of Mineland Reclamation and OSM.

2. Surface-water stations: Operated by company, USGS, and SEA. SEA maintains 6 lysimeters and monitors water use on reclaimed areas.

3. Ground-water wells: Operated by company and USGS.

4. Aquifer disruption: Not a problem. It occurs below coal seam in sandstone strata.

5. Air-quality station: Operated by company.

6. Weather stations: Maintained by company, ARS, and USGS.

7. Vegetation: Monitored by company which collects production and composition data on each reclaimed area. Reclamation regulations require permanent transects on undisturbed areas.

8. Trace elements uptake by plants: Monitored by USGS for sodium and calcium.

9. Comparison areas: Established in 1977 and specified by new regulation which requires 10 to 12 permanently marked reference areas.

10. Wildlife: Inventoried periodically by BLM Division of Wildlife. Usually done during spring calving-fawning and winter seasons.

11. Fisheries: Not affected because no impact on streams.

12. Several sediment basins: Located along Foidel Creek.

Company concerns with reclamation: BLM has good relationship with Energy Fuels for working on problems of surface-mined-land reclamation. However, there appears to be need for clarification of recent rules and regulations shown in 30 CFR, part 785.13, "Experimental Practices Mining," dated March 13, 1979.

## RECLAMATION PRESCRIPTION

A reclamation prescription is a variety of practices necessary to attain desired postmining conditions. These conditions are contained in the reclamation standard description for a proposed energy coal development that is based on premining conditions and potentials. Reclamation has been accomplished when topography, vegetation, surface runoff and ground-water characteristics reasonably approximate conditions determined for the stated postmining use(s). The objective is to develop a reclamation prescription for Major Land Resource Areas or subareas, as described in Agricultural Handbook 296. The following reclamation prescriptions, prescribed from data collected, are for the five Major Land Resource Areas included in this study.

Land Resource Region F - Northern Great Plains, Spring Wheat Region. Major Land Resource Area 54 - Rolling Soft Shale Plains (Agricultural Handbook 296).

Location: This prescription is based on data from the Indian Head Mine and research results by Mandan National Research Center on the Indian Head Mine near Zap, North Dakota, and the Glenn Harold Mine near Beulah, North Dakota.

Postmining Land Use: Cropland and native rangeland.

Revegetation Plan: All lands are seeded to a pasture seed mix to establish plant cover.

Shaping and Grading of Spoil: Shaping and grading are accomplished by a landscape plan. Water is developed by visual inspection and the landscape plans.

Topsoiling: Total suitable depth of soil will be removed in two lifts. First lift includes all the A horizon or a 6-in. minimum. Research shows increasing yields with increasing depth up to 2 ft of topsoil and 5 ft of subsoil. Stockpiling should be avoided for natural range areas. Depth of cut is determined by grid system.

Seed Mixture: No standard seed mixture is used. Species normally used are alfalfa; sweetclover; crested, intermediate, slender, pubescent, and western wheatgrass; smooth bromegrass; sideoats grama; and little bluestem.

Fertilization: No fertilization is generally used. Research shows benefits from N and P; therefore, N and P fertilizer are recommended, based on soil tests.

Surface manipulation: None used.

Mulch: None used.

Amendments: None used.

Irrigation: Not necessary practice.

Management: Fencing used as management practice to exclude livestock.

Water Harvest: Water reservoir developments are made to impound water that is needed for dust control and for wildlife habitat development.

Equipment Needs: None indicated.

Monitoring: Agency responsible for monitoring is North Dakota Public Service Commission. All aspects of air, water, vegetation, soils, and climate monitored.

Reclamation Sequence:

1. Spoil is spread and reshaped with bulldozers. Water developments are constructed at this time. The reshaping design is determined by landscape plan.

2. Soil is removed in two lifts and stockpiled. Total depth of profile is used including part of C horizon as part of the second lift. This is accomplished with scrapers. If proper timing can be attained, it is recommended that topsoil lifting and spreading be done in one operation.

3. No surface manipulations are used prior to seedbed preparation.

4. No seedbed preparation is done at Indian Head Mine. It is recommended that deep chiseling be done that extends into spoil deep enough to provide less abrupt contact between topsoil and spoil.

5. Seed mix is drilled in spring.

Recommendations:

1. A mulch crop should be grown and seed mix be drilled into the mulched surface. This would require light discing to crimp mulch and would provide adequate vegetative plant cover over winter and control erosion to an acceptable level during spring runoff.

2. More native species should be used in seed mixture for areas to be reclaimed to native range.

Land Resource Region G - Western Great Plains Range and Irrigated Region. Major Land Resource Area 58 - Northern Rolling High Plains.

Location: Based on data from Colstrip, Rosebud County, Montana.

Postmining Land Use: Native rangeland will be dominant use with small tracts of dryland farming.

Revegetation Plan: Revegetation to be done with seed mixture dominated by native species. Seven mixtures are used for different slope aspects. Cropland is also seeded to range species to stabilize and condition soil. (See page 24 for more detailed information on seed mixtures.)

Shape and Grading of Spoil: Grading and shaping done by visual inspection. Sediment ponds are developed.

Topsoiling: Removal done in two lifts with timing to avoid stockpiling. Soil removed to depth of 2-1/2 to 3 ft.

Seed Mixture: See item No. 3 under reclamation sequence.

Fertilization: First year, 175 lbs of 11-55-0 or 18-46-0 applied prior to seeding and rotation. Second year, 200 lbs of 16-20-0 applied in spring. Soil test should be used to establish exact amounts needed for second year.

Surface Manipulations: After grading and shaping, chiseling is done on all slopes. On slopes steeper than 7 to 1, gouging is recommended. Discing is done after fertilizing and mulching.

Mulching: Straw mulch is applied at 1-1/2 tons/A on slopes of less than 7 to 1. Hydromulch with wood fiber is used on slopes over 7 to 1.

Amendments: None used.

Irrigation: Not used.

Management: Fencing is only management practice presently recommended.

Water Harvest: Water used only for dust control. Water development not permitted by Montana rules and regulations.

Equipment Needs: None identified.

Monitoring: Conducted by Montana State Department of Lands. This includes surface-water stations, 32 wells, 6 high volume and 8 drop buckets for air quality and two weather stations. Soil is checked after seeding, and vegetation is checked against permanently established transect plots.

Reclamation Sequence:

1. Grading and shaping accomplished by bulldozers through visual inspection. Headwalls graded on a 5-to-1 slope.

2. Topsoil removed by scrapers and spread in same operation.

3. Reclamation sequence and revegetation process after topsoiling is completed:

a. Sample regraded spoils and redistributed topsoil. Samples will be analyzed according to the Department's current guidelines.

b. Topsoil is loosened by chisel plowing on contour. Chiseled area is fertilized with monoammonium phosphate using broadcaster. Fertilizer is applied to provide approximately 14 lbs of available N and 30 lbs of available P per acre. Final seedbed preparation consists of either rotavating or discing surface 4 in. of topsoil.

c. On slopes with gradients between 10 to 1 and 7 to 1, 3000 to 4000 lbs of wheat straw or native grass hay is applied per acre following chisel plowing. Straw or hay will be applied with modified manure spreader or stakprocessor. Both straw and fertilizer are incorporated to depth of 4 to 6 in. with rotavator.

d. Revegetation areas should be divided into Postmine Management Units as described below. Each management unit will represent particular plant community type or combination of types that exists in area prior to mining. These plant community types documented in premine vegetative surveys were conducted by ECON INC. of Helena, Montana. Seeding mixtures and indigenous species selected for transplanting in Postmine Management Units are at the end of this section.

Postmine Management Units are as follows:

(1) Wetland/Riparian: Small zonal areas confined to lower stretches of reconstructed drainages and around water impoundments. Species selected for revegation will be adapted to high moisture sites and will include those varieties that represent quality wildlife habitat.

(2) Lowland/Drainage: Reconstructed drainages and lowland run-in sites that will return to same state as existed prior to mining. These are ephemeral drainage areas receiving excess precipitation runoff from surrounding sites, thus effectively increasing soil moisture content. These areas will contain stabilizing grass, shrub, and tree species that will provide food and cover for both wildlife and domestic livestock.

(3) Uplands: Areas that occur on level, nearly level and moderate slopes. This is a major grassland type that is interspersed with various shrub associations, providing food for both wildlife and domestic livestock.

(4) Steep Uplands: Areas that occur on slopes of 10:1 or greater. These are also grassland types, mixed with open stands of conifers and various shrub associations. These areas contain food and cover for both wildlife and domestic livestock.

(5) Conifer Zones: Areas located at summit of reconstructed hilltops. These areas will be characterized by conifer-shrub vegetation complexes. This unit is associated primarily with wildlife habitat and will serve to provide food and cover for various wildlife species.

e. Grassland seed mixtures will be formulated to include those species occurring naturally in premine vegetation surveys, as represented in each Postmine Management Unit. Tree and shrub species will conform to the same code and will be reestablished with the use of the Vermeer tree spade, in conjunction with various seeding and propagation techniques currently being researched in the field of postmine revegetation techniques both at the Rosebud Mine and on other Northern Great Plains mine sites.

f. Reconstruction of Postmine Management Units will involve a period of from one to three years. Transplanting and interseeding of various tree, shrub, and forb species for use by both wildlife and domestic livestock will occur then.

g. Establishing permanent grassland seeding mixtures will be delayed from one to two years so that proper establishment of trees, shrubs, and forbs can take place without competition from the aggressive native grass species. During this period, winter graze will be seeded as a soil stabilizer at the rate of 5 to 10 lbs/A (PLS).

h. Permanent grass mixtures will be seeded with the Brillion seeder into the winter graze stubble. Surface Seedbed Scarifier will be used to loosen soil for planting while causing minimal disturbance to native plant species that have germinated and established themselves from redistributed topsoil.

i. Seeding rates for grassland mixes will be 20 lbs/A (PLS) to provide adequate space for encroachment of native species from undisturbed sites nearby. There will also be supplemental mixture that will be broadcast with Cyclone broadcaster prior to seeding with the Brillion. The mixture will be broadcast on all Management Units except the Wetland/Riparian Zone, which will be a mixture of native indigenous plants that have a lot of pubescence or long awns that make them hard to seed through a box-type drill. Many of these species will come from seed collected locally and mixed to insure proper PLS levels.

j. Seeding periods will be primarily fall (late August to late September) and late fall (after October 15th). Spring seeding will occur only if weather and field conditions warrant, and chances of successful seed emergence and establishment seem inevitable.

k. Where conditions warrant, slopes with greater than a 7:1 gradient will be gouged and seeded with the modified gouger/seeder. Gouging will be done along contour following incorporation of the fertilizer.

l. On slopes 7:1 or greater slopes, wood fiber will be applied at 2000 lbs/A as a hydromulch using the hydroseeder.

m. Selected reaches along bottoms of reconstructed drainages will be sodded for erosion control and as source of native seeds. To the extent possible, native sod will be transplanted from premine drainages.

## WETLAND/RIPARIAN MIXTURE

| Common Name | Scientific Name | % Total Mix (PLS)* |
|---|---|---|
| Switchgrass | Panicum virgatum | 60 |
| Prairie cordgrass | Spartina perctinata | 30 |
| Alkali bluegrass | Poa juncifolia | 10 |

## LOWLAND/DRAINAGE MIXTURE

| | | |
|---|---|---|
| Rosana western wheatgrass | Agropyron smithii | 30 |
| Slender wheatgrass | Agropyron trachycaulum | 20 |
| Thickspike wheatgrass | Agropyron dasystachyum | 10 |
| Mountain brome | Bromus marginatus | 10 |
| Kentucky bluegrass | Poa pratensis | 10 |
| Canada bluegrass | Poa compressa | 10 |
| Canada wildrye | Elymus canadensis | 10 |

## UPLANDS MIXTURE

| | | |
|---|---|---|
| Rosana western wheatgrass | Agropyron smithii | 30 |
| Critana thickspike wheatgrass | Agroypron dasystachyum | 20 |
| Green needlegrass | Stipa viridula | 20 |
| Slender wheatgrass | Agropyron trachycaulum | 10 |
| Prairie sandreed | Calamovilfa longifolia | 10 |
| Sideoats grama | Bouteloua curtipendula | 10 |

## STEEP UPLANDS MIXTURE

| | | |
|---|---|---|
| Rosana western wheatgrass | Agropyron smithii | 25 |
| Green needlegrass | Stipa viridula | 25 |
| Sideoats grama | Bouteloua curtipendula | 15 |
| Bluebunch wheatgrass | Agropyron spicatum | 15 |
| Thickspike wheatgrass | Agropyron dasystachyum | 10 |
| Prairie sandreed | Calamovilfa longifolia | 10 |

## CONIFER ZONE MIXTURE

| | | |
|---|---|---|
| Lodorm green needlegrass | Stipa viridula | 25 |
| Sideoats grama | Bouteloua curtipendula | 25 |
| Indian ricegrass | Oryzopsis hymenoides | 25 |
| Bluebunch wheatgrass | Agropyron spicatum | 15 |
| Rosana western wheatgrass | Agropyron smithii | 5 |
| Critana thickspike wheatgrass | Agropyron dasystachyum | 5 |

## SUPPLEMENTAL MIXTURE

| Common Name | Scientific Name | % Total Mix (PLS)* |
|---|---|---|
| Needleandthread | Stipa comata | 20 |
| Indian ricegrass | Oryzopsis hymenoides | 20 |
| Big bluestem | Andropogon gerardi | 10 |
| Sand bluestem | Andropogon hallii | 10 |
| Little bluestem | Andropogon scoparium | 5 |
| Fourwing saltbush | Atriplex canescens | 5 |
| Winterfat | Eurotia lanata | 5 |
| Blue grama | Bouteloua gracilis | 5 |
| Lewis flax | Linum lewisii | 5 |
| Prairie coneflower | Ratibida columnifera | 5 |
| Western yarrow | Achillea millefolium lanulosa | 5 |
| Purple prairie-clover | Petalostemon purpureum | 3 |
| White prairie-clover | Petalostemon candidum | 2 |

*Total mix PLS (pure live seed) based on number of seeds per pound of each species. Seeding rates = 20 lbs/A PLS. Winter graze will be planted at 5 to 10 lbs/A (PLS).

## INDIGENOUS TREES AND SHRUBS FOR REVEGETATION

| Common Name | Scientific Name |
|---|---|
| Boxelder | Acer negundo |
| Silver sagebrush | Artemisia cana |
| Big sagebrush | Artemisia tridentata |
| Rubber rabbitbrush | Chrysothamnus nauseosus |
| Green rabbitbrush | Chrysothamnus viscidiflorus |
| Fleshy hawthorn | Crataegus succulenta |
| Green ash | Fraxinus pennsylvanica |
| Rocky Mountain juniper | Juniperus scopulorum |
| Ponderosa pine | Pinus ponderosa |
| Narrowleaf cottonwood | Populus angustifolia |
| Plains cottonwood | Populus sargentii |
| American plum | Prunus americana |
| Chokecherry | Prunus virginiana |
| Skunkbush sumac | Rhus trilobata |
| Golden currant | Ribes aureum |
| Squaw currant | Ribes cereum |
| Redshoot gooseberry | Ribes setosum |
| Woods rose | Rosa woodsii |
| Peachleaf willow | Salix amygdaloides |
| Tealeaf willow | Salix phylicifolia |
| Western snowberry | Symphoricarpos occidentalis |
| Buffaloberry | Sheperdia argentea |
| Yucca | Yucca glauca |

## INDIGENOUS FORBS AND HALFSHRUBS FOR REVEGETATION

| Common Name | Scientific Name |
|---|---|
| Western yarrow | Achillea millefolium lanulosa |
| Prairie onion | Allium textile |
| Bluestem pricklypoppy | Argemone intermedia |
| Plains milkweed | Asclepias pumila |
| Groundplum milkvetch | Astragalus crassicarpus |
| Slender milkvetch | Astragalus gracilis |
| Missouri milkvetch | Astragalus missouriensis |
| Fourwing saltbush | Atriplex canescens |
| Arrowleaf balsamroot | Balsamorhiza sagittata |
| Sego (mariposa) lily | Calochortis nuttallii |
| Roundleaf harebell | Campanula rotundifolia |
| Largeflowered Indian paintbrush | Castilleja sessiflora |
| Winterfat | Eurotia lanata |
| Rocky Mountain beeplant | Cleome serrulata |
| Purple coneflower | Echinacea pallida |
| Annual eriogonum | Eriogonum annuum |
| Plains wallflower | Erysimum asperum |
| Blanketflower | Gaillardia aristata |
| Ballhead gilia | Gilia congesta |
| Prairie sunflower | Helianthus petiolaris |
| Northern sweetvetch | Hedysarum boreale |
| White sweetvetch | Hedysarum sulpherescens |
| Dotted gayfeather | Liatris punctata |
| Lewis flax | Linum lewisii (perenne) |
| Narrowleaf gromwell | Lithospermum incisum |
| Tenpetal blazing star | Mentzelia decapetala |
| Tufted eveningprimrose | Oenothera caespitosa |
| Shrubby eveningprimrose | Oenothera serrulata |
| White penstemon | Petalostemon albidus |
| White prairie-clover | Petalostemon candidum |
| Purple prairie-clover | Petalostemon purpureum |
| Prairie goldenpea | Thermopsis rhombifolia |
| Silverleaf scurfpea | Psoralea argophylla |
| Prairie coneflower | Ratibida columnifera |
| American vetch | Vicia americana |

Recommendations for Land Resource Region G:

1. Water development should be permitted at mines where there is no potential for chemical contamination. Water is needed for dust control and in the future for livestock and wildlife, which could be done at no additional cost because landscape must be shaped and equipment is there to do the job.

2. Hydromulching is not too successful on steeper slopes because it washes off. It could be replaced by straw mulching incorporated in soil with greater success.

3. In seed mixture low amounts of native sagebrush should be included to make stands similar to native composition.

4. Sodding of drainageways with native sod material was successful. This is recommended in higher precipitation areas where erosion is potential hazard.

Resource Planning Unit D - Western Range and Irrigated Region. Major Land Resource Area - 33 Semiarid Rocky Mountains and 34 Central Desertic Basins, Mountains and Plateaus.

Location: Based on data from Dave Johnston Mine, Glenrock, Wyoming; and Seminoe 1 Mine, Hanna, Wyoming.

Postmining Land Use: Native-type rangeland will be the land use.

Revegetation Plan: Objective to reclaim mined areas to vegetation cover equal or better than natural native rangeland.

Shape and Grading of Spoil: Shaping and grading to original surface contour with bulldozers done by visual inspection and use of contour map. No water developments permitted by State regulations.

Topsoiling: Maximum thickness up to 3 ft of soil including C horizon material should be used, which should include two lifts, the first lift the upper 6 in. Soil should be lifted and replaced in one operation. Lifting and spreading done by scrapers. Final spreading also done with road graders for more uniform spreading.

Surface Manipulations: Chisel plowing through topsoil into spoil recommended, which provides good contact and disruption of surface-spoil compaction.

Seed Mixture: Being used and includes following at rate of 15 lbs/ac:

| Common Name | Scientific Name | Percent |
|---|---|---|
| Wyoming sagebrush | Artemisia tridentata | 5 |
| Crested wheatgrass | Agropyron desertorum | 10 |
| Thickspike wheatgrass | Agropyron dasystachyum | 23 |
| Bearded wheatgrass | Agropyron caninum | 18 |
| Indian ricegrass | Oryzopsis hymenoides | 5 |
| Yellow sweetclover | Helilotus | 5 |
| Fourwing saltbush | Atriplex canescens | 10 |

Fertilization: Not recommended because minimum of 12 in. of precipitation required for response with fertilizers.

Mulch: Recommended that mulch crop of millet be grown and seed mixture be planted into millet straw in the fall. Millet is better crop in low moisture areas than winter grain and also provides food for birds and animals. Both millet and winter grain are now being used. Straw is not recommended because it would provide weed seed and also retard germination in low rainfall areas.

Amendments: None recommended.

Irrigation: Not recommended. It could be used for seedling establishment when water is not available. Seedling establishment can be obtained without irrigation in most years.

Protection Management: Fencing used to protect reclaimed areas from livestock grazing. Rock piles used and recommended for bird and small mammal habitats.

Water Harvest: No water development permitted by State regulations.

Equipment Needs: None suggested.

Monitoring: Wyoming State Department of Environmental Quality in charge of monitoring and is required to do part of monitoring. Surface-water and ground-water wells monitored by USGS.

Management: None used by the mines. Water development and grazing not permitted by State rules and regulations.

Reclamation Sequence:

1. Spoil shaped and graded based on visual inspection. Topographic maps should be used as a guide.

2. Topsoil stripping by scrapers recommended to be done in two lifts utilizing all of soil profile plus enough of C horizon to give approximately 32 in. of soil over spoil. Present methods use one lift that gives an average of 6 in. of soil over spoil. Spreading presently done by bulldozer or combination of bulldozer and grader. Grader is used to make terraces with final grading of topsoil.

3. Chisel plowing into spoil is recommended. Ripping of spoil prior to topsoiling is not recommended.

4. Millet is planted in spring for mulch crop.

5. Seed mixture drilled into mulch straw in fall.

Recommendations:

1. Soil should be lifted into two lifts to permit establishing native species from seed in topsoil. It is also strongly recommended that more of the C horizon be used to give greater depth of soil for moisture storage and root development. An average of 6 to 12 in. of soil now being spread is not enough for good planting establishment. Many of the soils are sandy; therefore, it is even more important that a greater thickness of soil be used.

2. Slender wheatgrass generally used should be dropped out of mixture because it is a higher moisture-loving plant. Additions to seed mix could be bearded wheatgrass (Agropyron subsecundum), Russian wildrye (Elymus junceus), and Wyoming sagebrush.

3. Water development ponds should be permitted, which could be the use of sections of coal pits that develop water and have no chemical contamination. Water is scarce and such developments would not add to reclamation cost.

4. Terrace development is used at one mine. The success of these terraces should be studied further before recommendations for their use are made. Most places have found terraces to be undesirable because they accelerate erosion due to buildup of water and breaking through to the next terrace; this may not be a problem in low rainfall areas.

5. In low rainfall areas, millet is recommended over grain as a mulch crop because it is more drought tolerant and provides food for birds and other wildlife.

Major Land Resource Region Unit D - Western Range and Irrigated Region. Major Land Resource Area - 37 San Juan River Valley Mesas and Plateaus.

Location: Based on data from San Juan Mine west of Farmington, New Mexico.

Postmining Land Use: Reclamation is directed toward native rangeland.

Revegetation Plan: To develop a plant community as close as possible to the native range, which includes shadscale, fourwing saltbush and blue grama. Revegetation designed to closely approximate native plant community. Establishing vegetation is to be done by irrigation for the first two years.

Shape and Grading of Spoil: Done by bulldozers to approximate preexisting topography from visual inspection and topography maps.

Topsoiling: Done in two lifts using total depth of profile, which should be deep enough to include C horizon but not into overburden, if salty or clayey, to give at least 24 in. of soil when respread.

Surface Manipulation: Deep discing or chiseling done after topsoiling. Terraces called "water harvest terraces" have been developed by research that give greater yields than nonterrace areas.

Seed Mixture: The following is recommended: Indian ricegrass, sand dropseed, blue grama, yellow bluestem, streambank wheatgrass, galleta, fourwing saltbush, and winterfat.

Fertilization: Sixty lbs of N and 80 lbs of triple super phosphate in one application. Soil testing should be done to determine exact amount needed.

Mulch: Required by State law--4000 lbs. With this much straw, the amount of N should be added to prevent seedling growth retardation.

Amendments: None recommended.

Irrigation: Necessary to establish vegetation and done for two years. The first year 16 in. is used, the second year 8 in. of water is used.

Protection: Fencing used on reclaimed areas.

Water Harvest: No local water available except from the San Juan River. This is used first through the power plant, and water is used for road dust control and irrigation.

Equipment Needs: None given for San Juan Mine.

Monitoring: Agenices responsible for monitoring are New Mexico Pit Mining Commission Company, USGS, and OSM. Surface water, ground water, vegetation, soil, air, and climate are monitored.

Management: No special grazing management techniques recommended.

Reclamation Sequence:

1. Grading and shaping of spoil done by bulldozers.

2. Topsoil stripped by scrapers in two lifts and stockpiled. It is recommended that this be done in one operation if timing can be developed to permit it.

3. Topsoil spread.

4. Fertilizer applied.

5. Surface deep disced or chiseled.

6. Seed drilled.

7. Mulch spread and crimped.

8. Irrigation done by sprinkler system.

Recommendations: The reclamation prescription presented is that being used at San Juan Mine and is working very well so no further recommendation can be offered without further investigations into other mines. Water and soil depth seem to be problems but salts and clays could be problems in some areas and could require some modification in prescription. Water-collecting terraces may be a desirable practice to increase vegetative growth.

Major Land Resource Region Unit E - Rocky Mountain Range and Forest Region. Major Land Resource Area - 48 Southern Rocky Mountains.

Location: Based on Edna and Energy Mines located near Steamboat Springs in northwestern Colorado.

Postmining Land Use: Land use is 80 percent native rangeland and 20 percent or less wheatland.

Shape and Grading of Spoil: Grading and shaping done by bulldozers and road graders through visual inspection and use of topographic maps.

Topsoil: Total soil depth should be used to give a minimum of 3 ft of soil. This should be done in two lifts. Present practices do the soil removal in one lift.

Revegetation Plan: Area will be revegetated to approximate native rangeland or winter wheat cropland. Presently all areas seeded with seed mixture for range use.

Surface Manipulation: Chiseling, discing, and contour furrowing used. Soil smoothed with a road grader.

Seed Mixture: Amount could vary from 12 to 15 lbs/A.

GRASSES

| Common Plant Name | Scientific Plant Name | Pounds |
|---|---|---|
| Slender wheatgrass | Agropyron trachycaulum | 2.00 |
| Intermediate wheatgrass | Agropyron intermedium | 1.50 |
| Pubescent wheatgrass | Agropyron trichophorum | 1.50 |
| Western wheatgrass | Agropyron smithii | 1.00 |
| Great Basin wildrye | Elymus cinereus | .25 |
| Idaho fescue | Festuca idahoensis | 1.00 |
| Hard fescue | Festuca ovina duriuscula | .25 |
| Mountain brome | Bromus marginatus | 2.00 |
| Smooth brome | Bromus inermis | 2.00 |
| | Total grasses | 11.50 |

FORBS

| Common Plant Name | Scientific Plant Name | Pounds |
|---|---|---|
| Cicer milkvetch | Astragalus cicer | .50 |
| Yellow sweetclover | Melilotus | .50 |
| Arrowleaf balsamroot | Balsamorhiza sagittata | .01 |
| Small burnet | Sangvisorba minor | .50 |
| Sweetanise | Osmorhiza occidentalis | .50 |
| Alfalfa | Medicago sativa | .50 |
| | Total forbs | 2.51 |

SHRUBS

| Common Plant Name | Scientific Plant Name | Pounds |
|---|---|---|
| Mountain big sagebrush | Artemisia tridentata vaseyana | .50 |
| Antelope bitterbrush | Purshia tridentata | .50 |
| Lancelate bitterbrush | Purshia lanceolata | .50 |
| Chokecherry | Prunus virginiana | .50 |
| Serviceberry | Amelanchier sp. | .50 |
| | Total shrubs | 2.50 |

Fertilization: Fertilizers have not been demonstrated to be needed in these high organic matter soils; however, soil testing for fertility needs are recommended.

Mulch: Required and can be applied as straw or grown from annual grain crop.

Amendments: Not needed in this area.

Irrigation: Not needed.

Protection: Fencing is used to protect areas from grazing. Rock piles should be developed for bird and small mammal habitats.

Water Harvest: Water is used for road dust control.

Equipment Needs: (1) Better front-end loader for tree transplanting, (2) Improved planter for containerized plants, and (3) Seed-harvesting equipment for mountain brome.

Monitoring: Agencies responsible are: Colorado Division of Mineland Reclamation, BLM, EPA, USGS, and DOW. All aspects of water, air, soil, forage production, and climate monitored.

Management: No special management practices used.

Reclamation Sequence:

1. Grading and shaping may be done by visual inspection or landscape plan.

2. Topsoil removed in two lifts using full depth of soil profile in which soil is lifted and spread in one operation.

3. Topsoil smoothed with a road grader.

4. Seedbed chiseled and disced.

5. Seeding drilled into grown mulch in fall.

6. Mulch straw applied and crimped if straw used for mulch, but growing mulch seems to be better practice.

7. Area contour furrowed.

8. Trees transplanted and grouped in small groves.

Recommendations:

1. Present practice of soil removal is done in one lift. This definitely should be done in two lifts to take advantage of natural plant material source in surface soil.

2. Contour furrowing is new concept and works well to slow runoff and soil loss. This method should be considered in future mine operations.

3. Water developments should be permitted in this area where no hazards exist for livestock and wildlife. State laws do not presently permit water development. This regulation should be modified to permit water considerations for each project. It is known in advance if toxic chemicals from overburden have potential for a problem.

4. Tree transplanting with front-end loaders was proven to be a successful practice. It is recommended that this method be used in preference to tree spading, since it is much faster and less expensive to operate than tree spading.

## General Recommendations

1. Air photo coverage should be made yearly of each mine that is of importance to BLM. Both vertical and oblique are needed in infrared and color. Verticals should be made with 9X9 aerial camera. 35mm color made in stereo pairs would provide a technique for making more critical evaluations of the mine site from the air. This would provide a system for monitoring progress of reclamation, disturbance, and surface-water runoff.

2. Recommendations for continuation of mined-land reclamation data collected from additional coal mines are:

a. Additional mines are needed to provide broader data base for developing better prescriptions.

b. Similar data is needed on all coal mines to which BLM has a concern, which would contribute to developing a data file on each mine. This file would provide an accumulation of information on success and failure of standards and stipulations and could provide data needed to evaluate the effectiveness of present stipulations and standards.

c. Develop reference file for the Bureau on important reclamation information.

3. Consideration should be given to mine company's appraisal of regulations and stipulations that are thought to be impractical or noneffective.

4. Recommendations for updating the Guidelines for Reclamation Study Areas--EMRIA Handbook 1977.

a. Show basic investigation methods or procedures used.

b. Need more illustrations: Examples of soil maps, interpretations, plant lists, and communities.

c. Improve format.

5. Educational or training program for company mine reclamationist is recommended. Should be BLM responsibility, assisted by JEA or State University and State regulatory agencies. Mine superintendents and reclamation specialists frequently do not understand why and how a stipulation is made on the ground. Too often they must follow recommendations of the consultant who prepares from a canned plan. Most reclamationists do not understand soil and the use of soil surveys; thus, training is needed in this area.

6. BLM should define differences between rules, regulations and stipulations. Stipulations should be developed to fit specific mine plant, and these should not be confused and mixed with the rules and regulations. Stipulations are specifications on "how to do it" for that particular mine. Environmental conditions vary from place to place, so a canned reclamation plan cannot fit every situation and must be designed to fit the local conditions.

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Dames & Moore. 1975. Baseline environmental report: Proposed coal mine expansion near Steamboat Springs, Routt County, Colorado, for Energy Fuels Corporation (unpublished data); 215 p., 1 plate, several maps.

(Personal Communications--1978)

San Juan Coal Mine

Allen, Robert, Superintendent or mine manager.
Calkins, Bob, BLM District Manager, Farmington, New Mexico.
Gebehart, Rodney, Reclamation specialist.
Gould, Dr. Walter, New Mexico State University, Vegetation study and inventory.
Kreager, Tim, BLM, Farmington, New Mexico.
Teigs, Bill, Preparation foreman.

Edna Coal Mine

Meachum, Tony, engineer.
Osborn, Lane, BLM Office, Craig, Colorado.
Scott, Dave, Reclamation specialist.
Washburn, Clarence, Mine superintendent.
Whetzel, Dr. Josh, Reclamation specialist; supervised comparison areas.

Energy Fuel Mines 1 and 2

Brown, William R. (Rick), Mine superintendent.
Croft, Kent, Company range scientist.
Osborn, Lane, BLM Office, Craig, Colorado.

Indian Head Coal Mine

Becker, Jerry, Pit director.
Brown, J., Reclamation specialist.
Brown, Terry, Reclamation specialist.
Mitzel, Joe D., Mine superintendent.
Pitman, Jerry, BLM D.O., Dickinson, North Dakota.
Sandoval, Fred, SEA.
Waldhaus, Fred, BLM S.O., Billings, Montana.

Rosebud Coal Mine

Cull, Chris, Early Murray, Dick Bassett, and Pete Mellbom, Reclamation specialists.
Hanson, Jackie, Company reclamation specialist.
Wood, Tim, Mining supervisor.

Dave Johnston Coal Mine

Harrington, Neil, former Reclamation director.
Hartley, Don, new Reclamation director.
Tehaka, Larry, Superintendent.

(Personal Communications--1978)

Seminoe Coal Mine

Bierei, Greg, and Fred Newman, Company reclamation specialists.
Kieper, Dave, Superintendent.
Montone, Steve, Resident engineer.

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